HYDRO ENERGY POTENTIAL OF COOLING WATER AT THE THERMAL POWER PLANT

Vladimir D. Stevanovic), Aleksandar Gajic*), Ljubodrag Savic**), Vladan Kuzmanovic**), Dusan Arnautovic***), Tina Dasic**), Blazenka Maslovaric*), Sanja Prica*), Bojan Milovanovic**)*

****)Faculty of Mechanical Engineering, University of Belgrade***

*****)Faculty of Civil Engineering, University of Belgrade***

******)Electrotechnical Institute "Nikola Tesla"***

A HYDRO POWER PLANT WITH A GENERATION CAPACITY OF 7.5 MWE USES THE AVAILABLE HYDRO ENERGY OF THE SEA WATER, WHICH SERVES AS A COOLANT FOR EIGHT UNITS OF A THERMAL POWER PLANT IN SOUTH KOREA

Reduction of carbon emissions by 13715 tons annually.

A PLANT WITH TWO HYDRO TURBINES WITH A POWER OF 5 MWe EACH HAS BEEN BUILT AT THE KOZLODUY NUCLEAR POWER PLANT IN BULGARIA

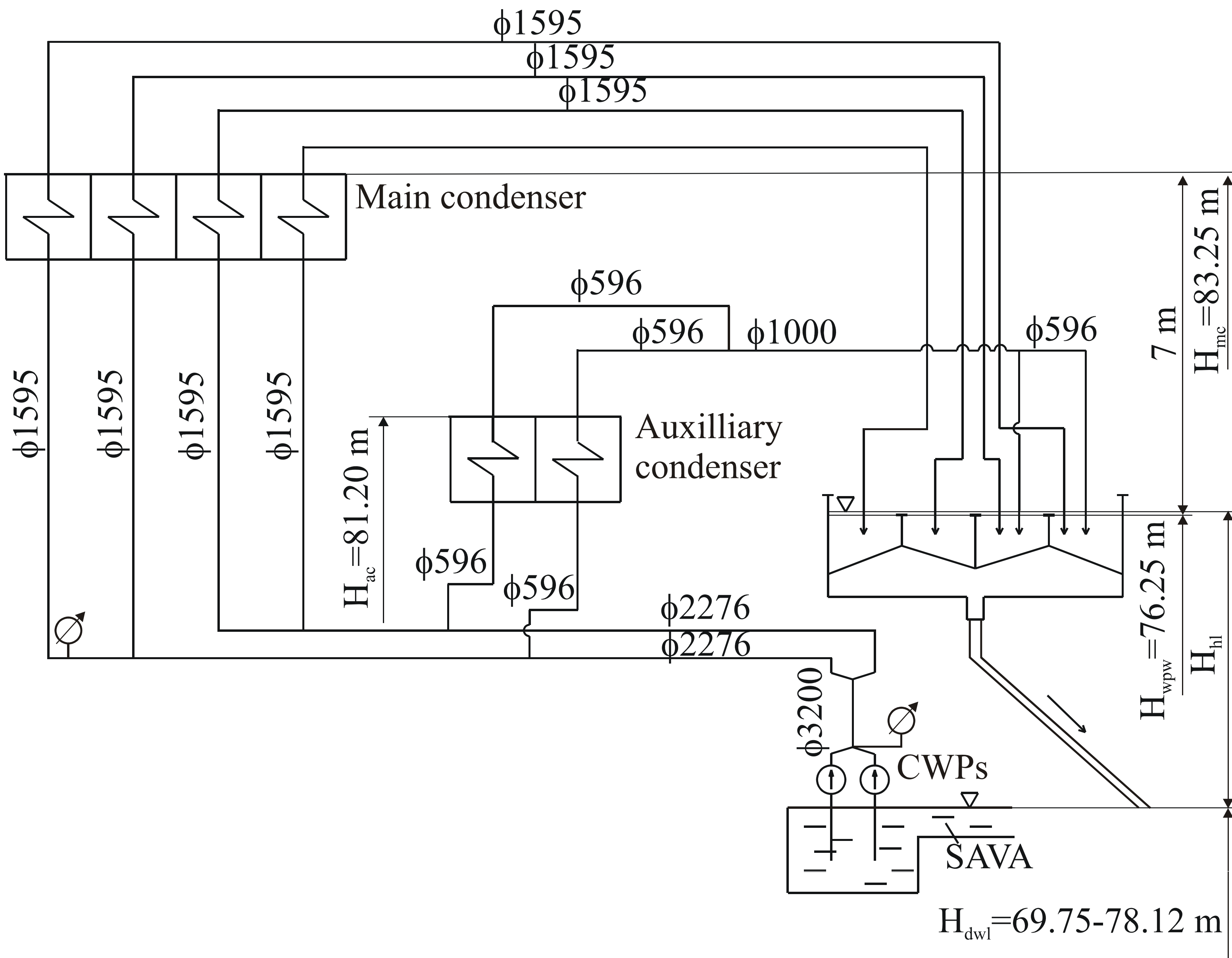
KOZLODUY NPP REVIEW

The English language bulletin of Kozloduy Nuclear Power Plant ❖ No.4 July-August, 2007

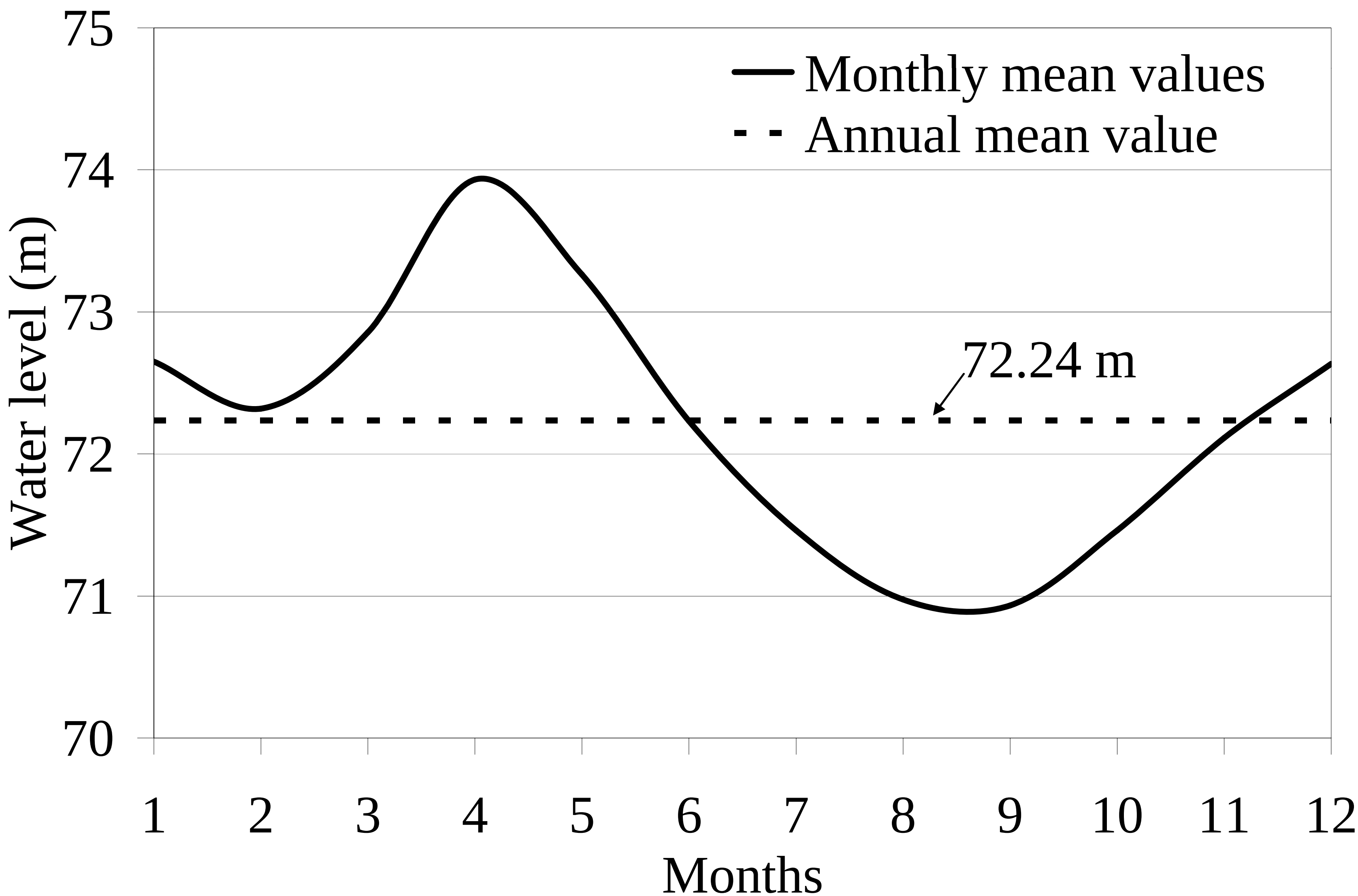
Kozloduy NPP started the hydro power plant project

A new hydroelectric power plant is under construction on the Kozloduy NPP's site. It is situated near the Bank Pumping Station and will be supplied with water from the cooling systems of Units 5 and 6.

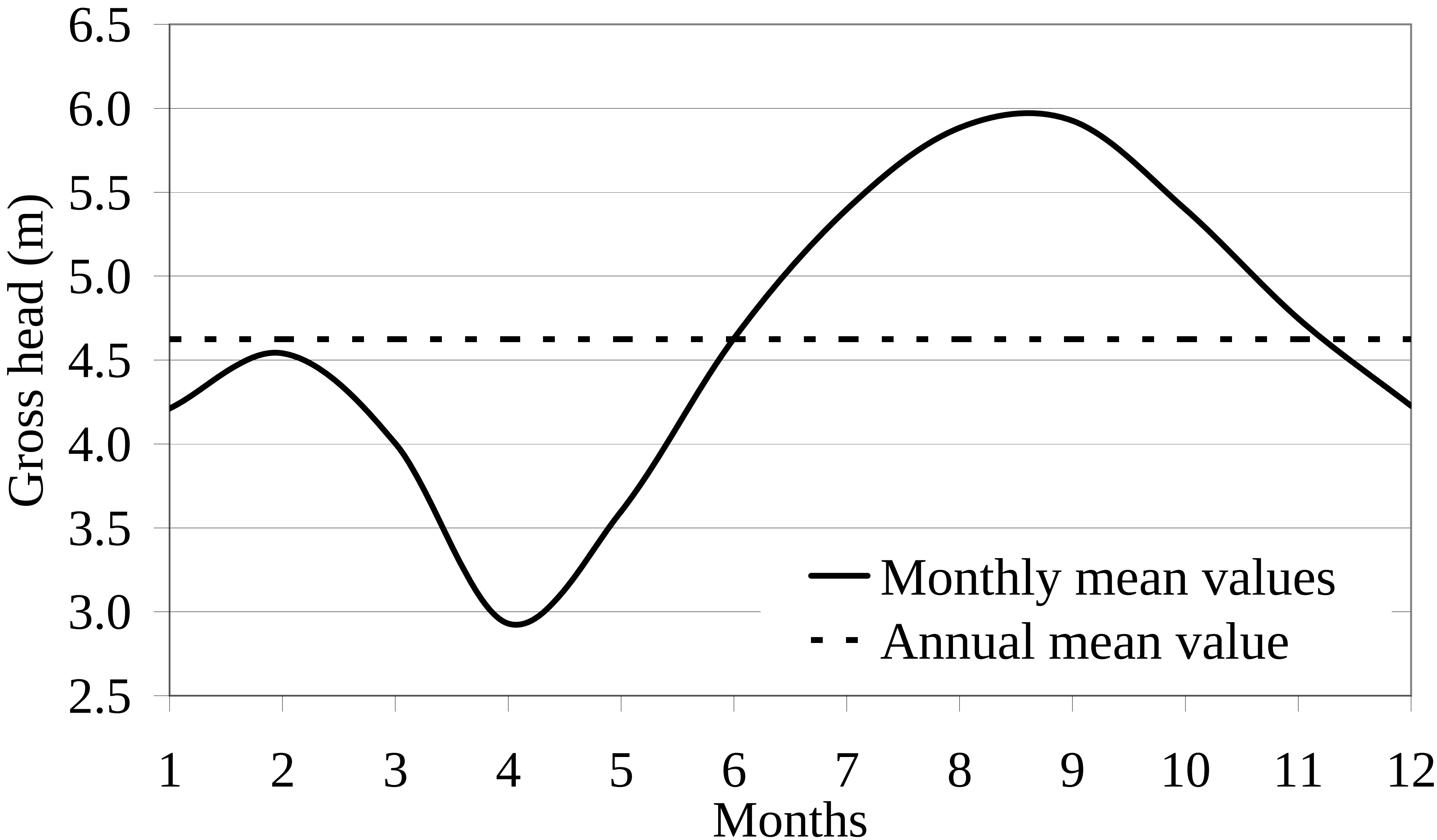
THE COOLING WATER SYSTEM AT ONE UNIT OF THE THERMAL POWER PLANT "NIKOLA TESLA B"



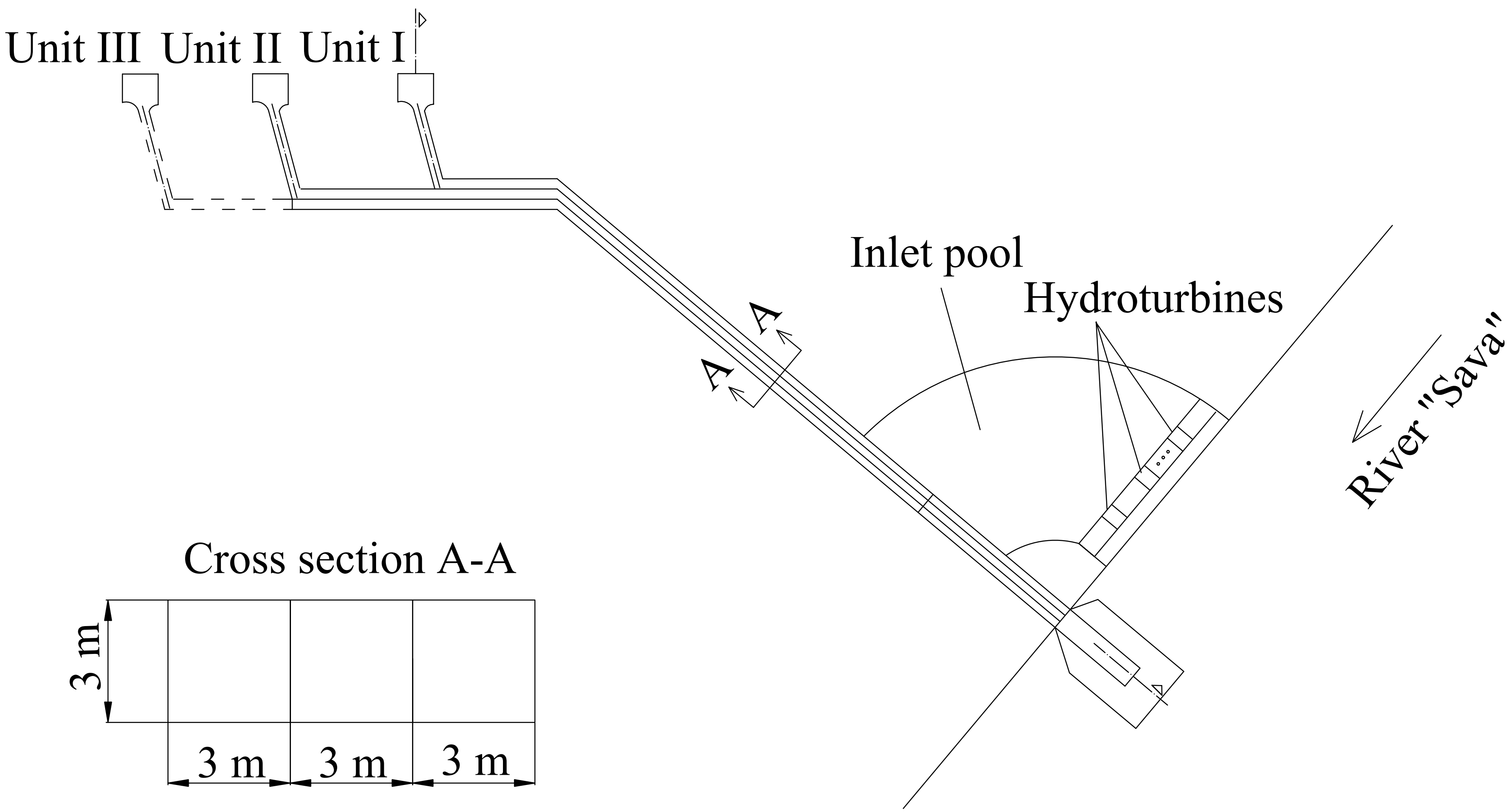
AVERAGED WATER LEVEL OF THE RIVER SAVA DURING THE YEAR BASED ON THE 20 YEARS DAILY RECORDS (FROM 1986 TILL 2006)



AVERAGED GROSS HEAD FROM THE SURFACE OF THE WATER POOL AT THE PLANT TILL THE RIVER LEVEL DURING THE YEAR BASED ON THE 20 YEARS DAILY RECORDS (FROM 1986 TILL 2006)



DISCHARGE COOLING WATER CHANNELS FROM THE POOLS AT THE PLANT UNITS TILL THE RIVER



HEAD LOSSES

LENGTH OF THE COOLING WATER DISCHARGE CHANNEL

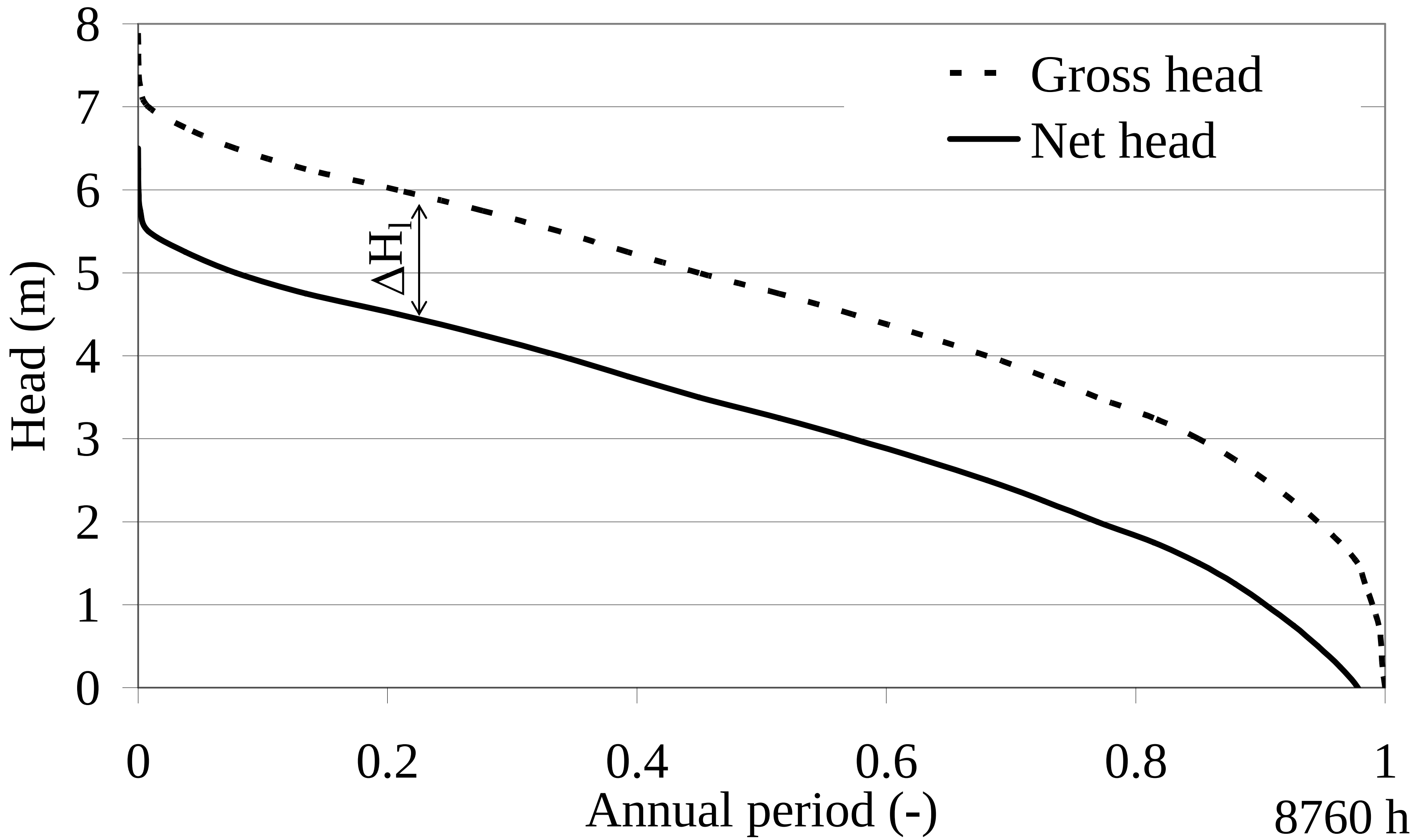
UNIT of TENT B	UNIT 1	UNIT 2	UNIT 3
LENGHT L_{1-4} (m)	470	545	620[1)]

1) Assumed

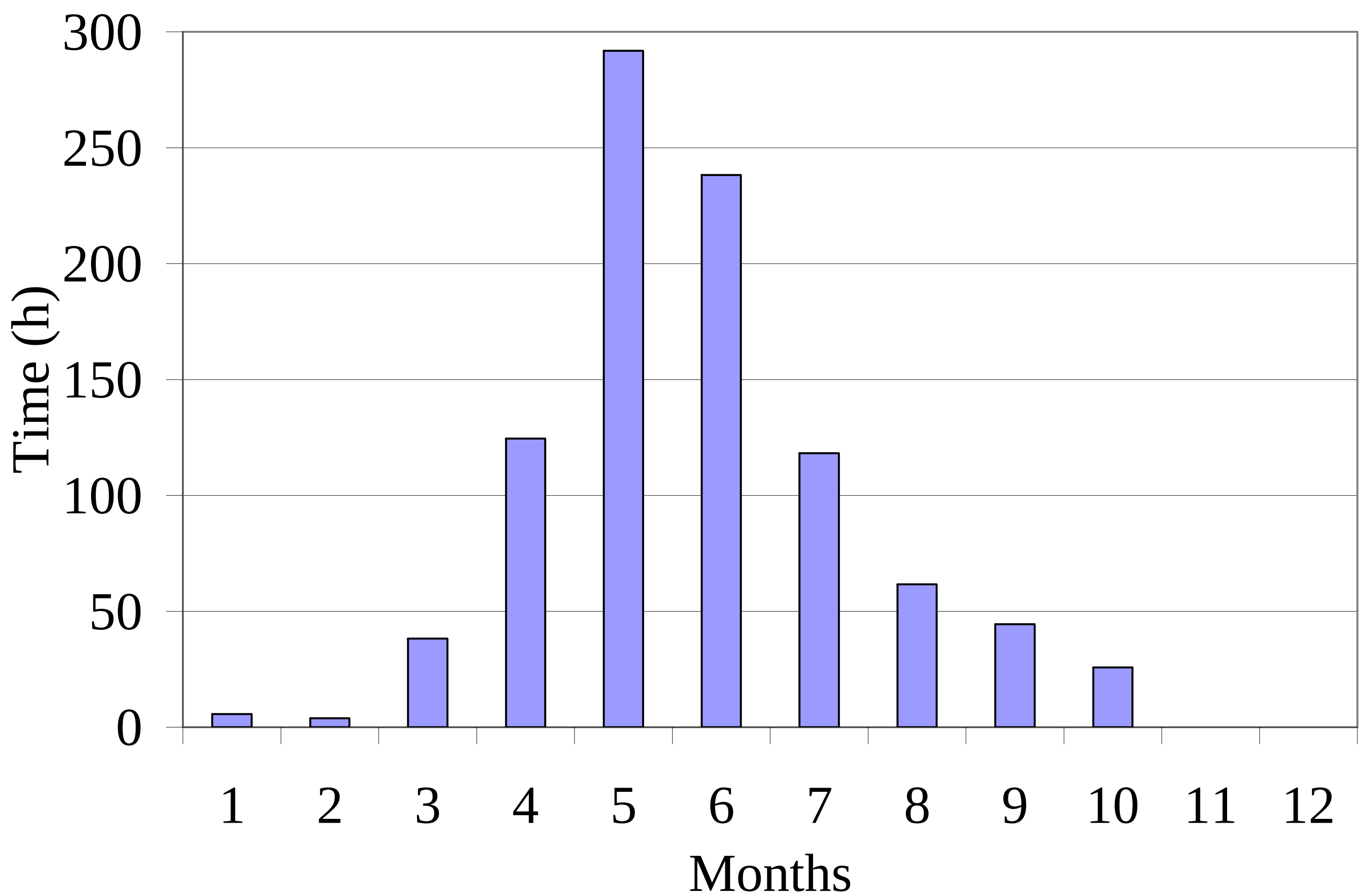
HEAD LOSS

UNIT of TENT B	UNIT 1	UNIT 2	UNIT 3
$\Delta H_g = H_b - H_n$ (m)	1.19	1.28	1.38

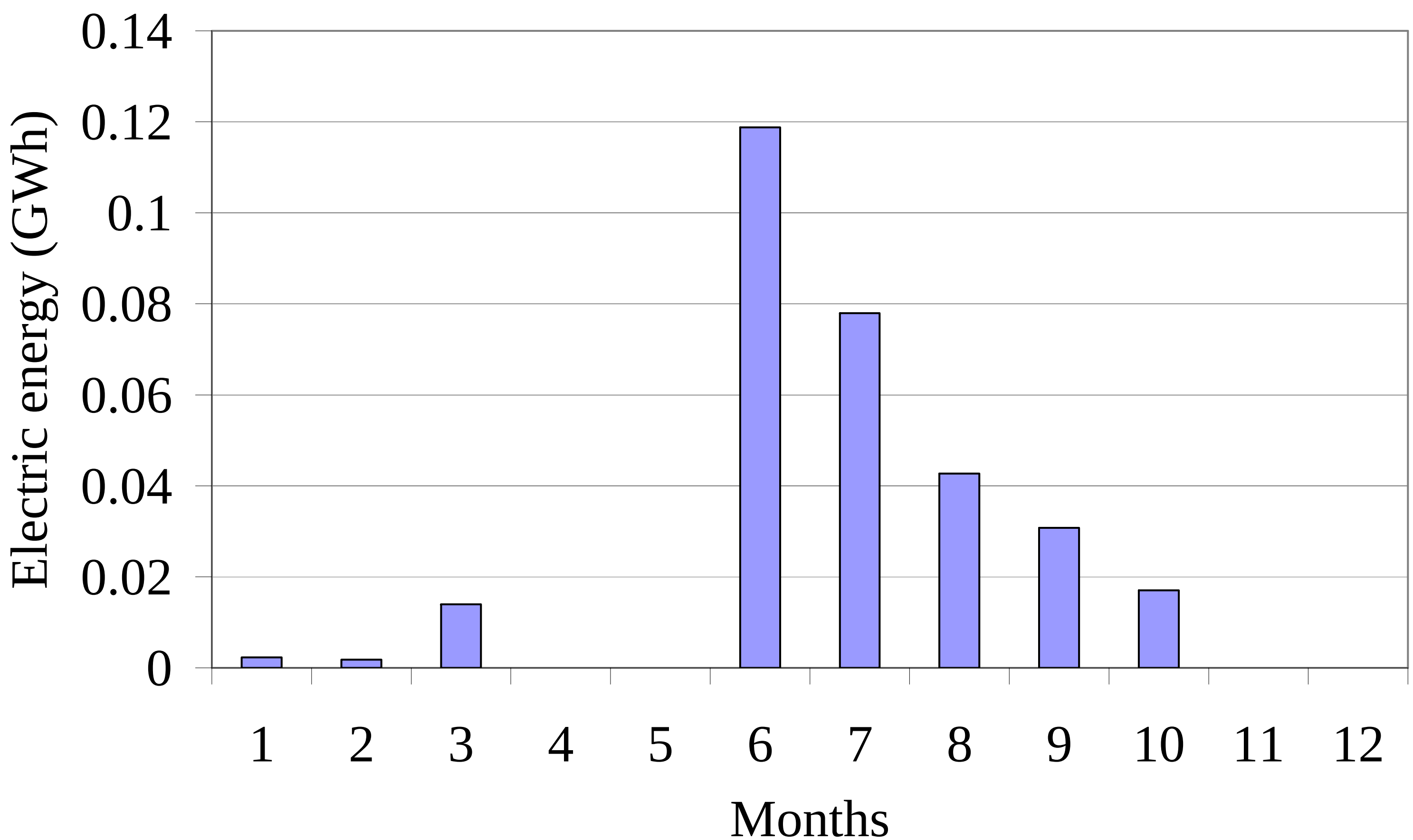
DURATION CURVES FOR THE GROSS AND NET HEADS FROM THE WATER POOLS IN THERMAL POWER PLANT UNITS TILL THE HYDRO POWER PLANT AT THE RIVER SAVA BANK (AVERAGED FOR THE PERIOD FROM THE YEAR 1986 TILL 2006)

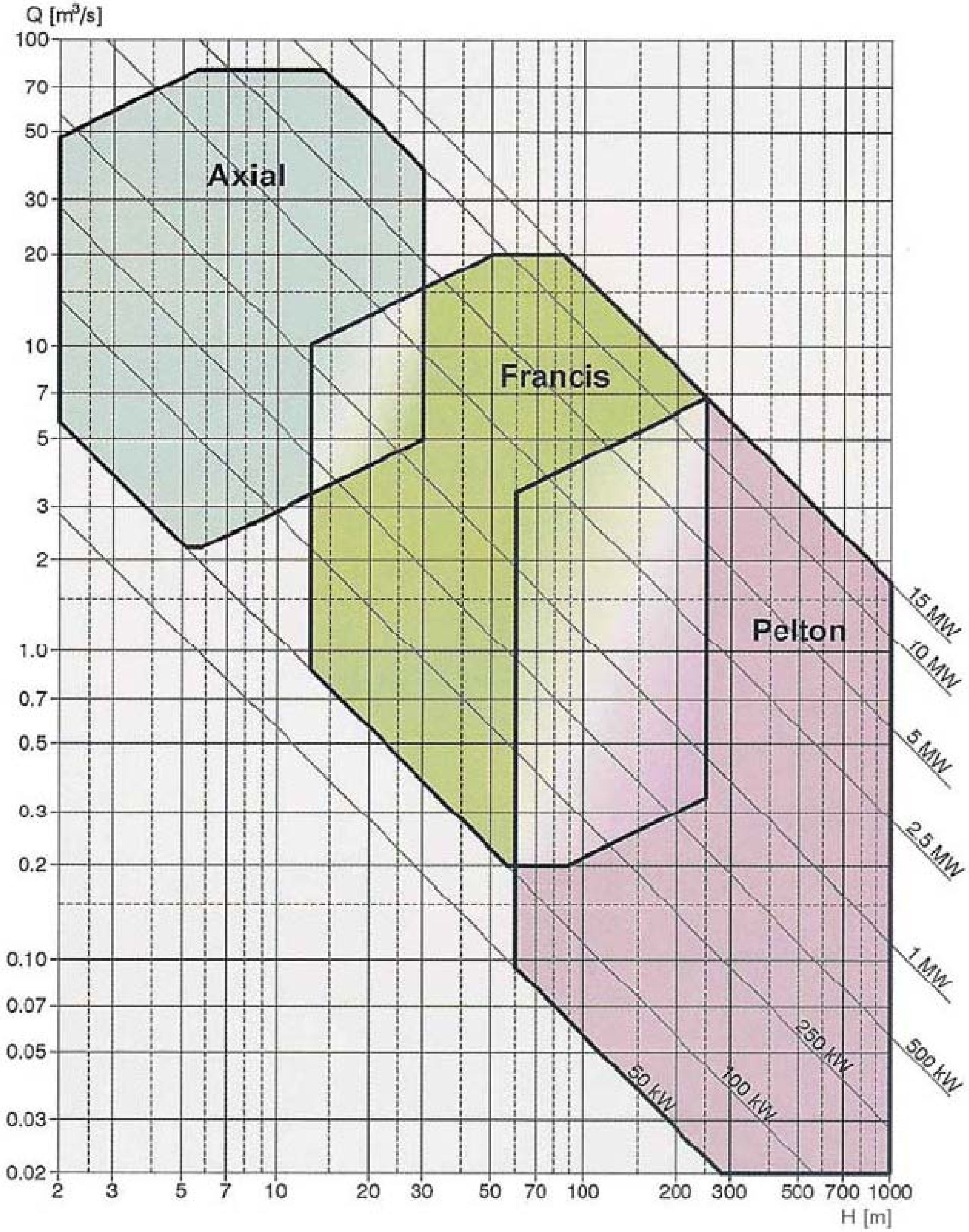


AVERAGE MONTHLY OVERHAUL PERIODS DURING THE YEAR PER ONE UNIT OF THE THERMAL POWER PLANT “NIKOLA TESLA B” (AVERAGED FROM THE FIRST CONNECTION TO THE GRID IN 1984 (UNIT 1) AND 1986 (UNIT 2) TILL JUNE 2007)



THE REDUCTION OF THE ELECTRICITY PRODUCTION AT THE HYDRO POWER PLANT DUE TO THE OVERHAULS IN ONE UNIT OF THE THERMAL POWER PLANT “NIKOLA TESLA B” (TOTAL ANNUAL REDUCTION IS 0.3052 GWH OF ELECTRICITY PRODUCTION IN CASE OF NO OVERHAUL PERIODS)

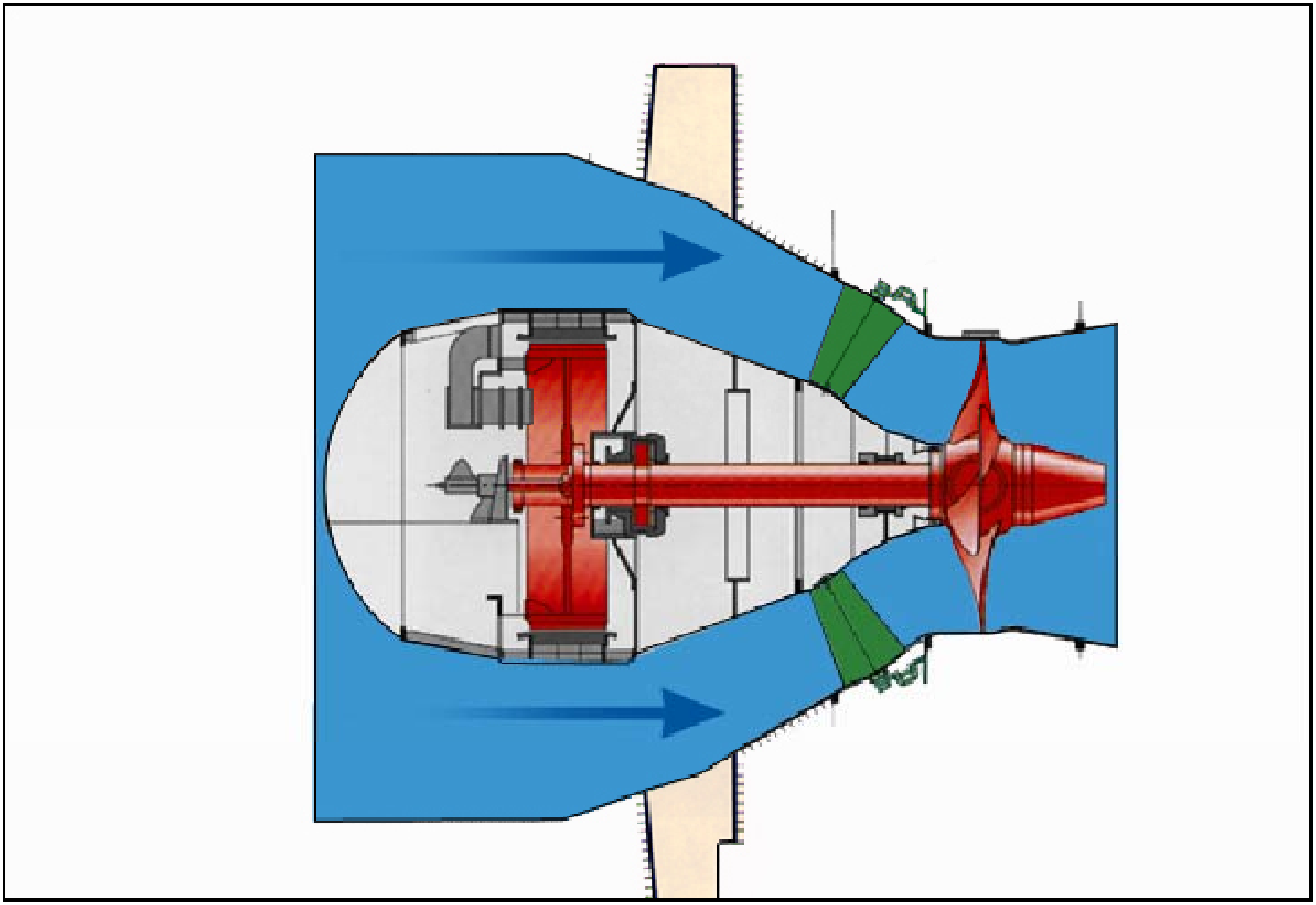




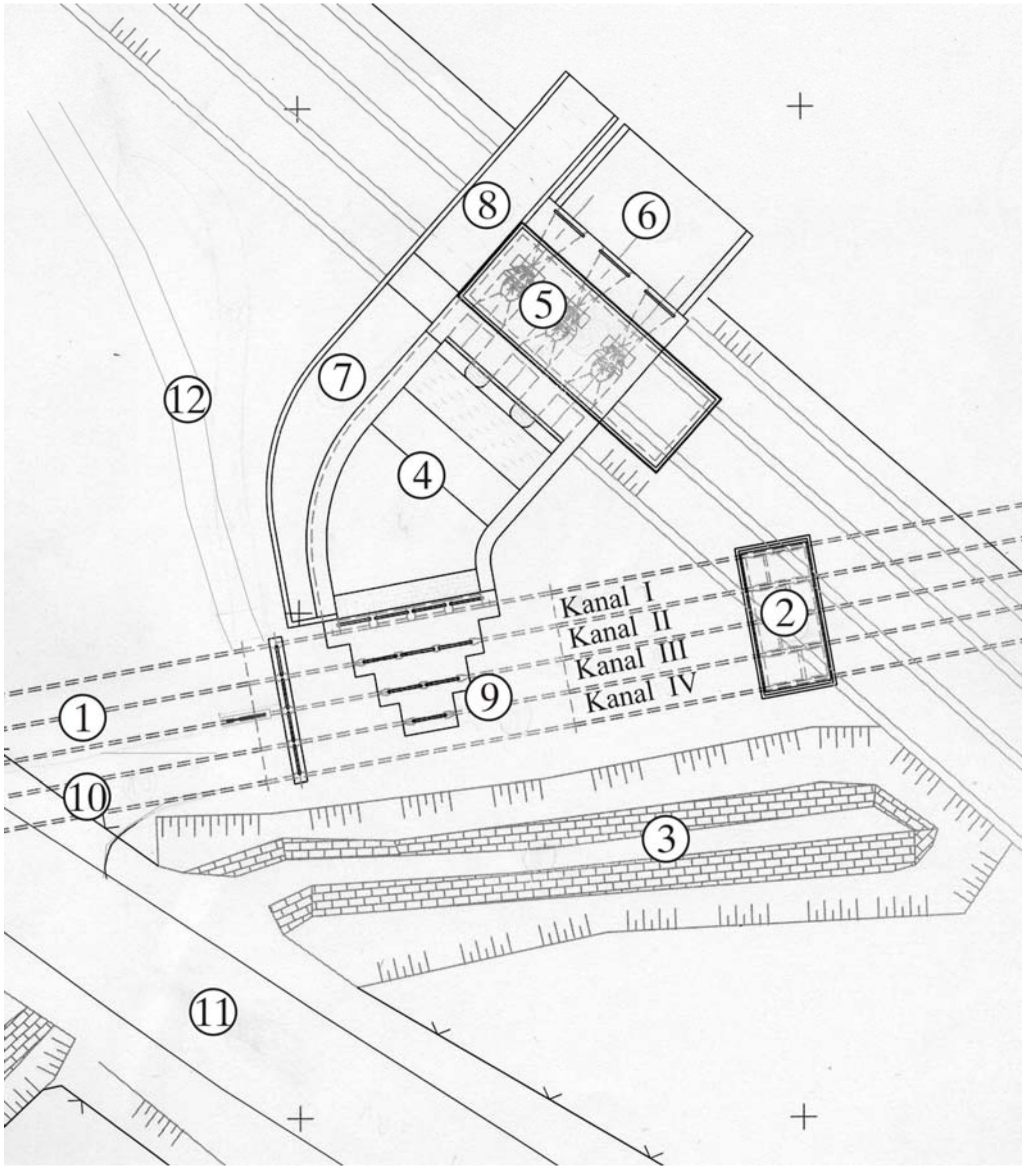
TURBINE'S TYPE FIELD OF APPLICATION

Reference: Guide on How to Develop a Small Hydropower Plant, European Small Hydropower Association - ESHA, Brussels, Belgium, 2004.

BULB TURBINE

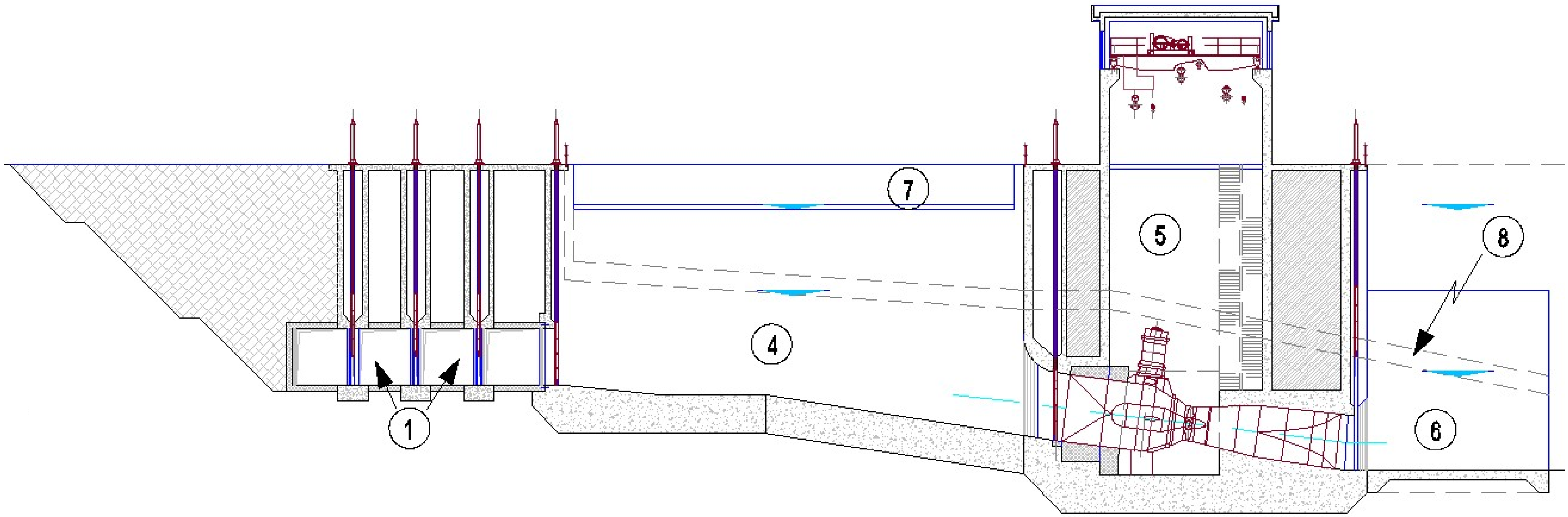


HYDRO POWER PLANT LAYOUT



Legend:
1. Cooling water flow
2. The existing outlet structure
3. The existing earth channel
4. The intake structure with the chamber
5. Power house
6. Tail water
7. Emergency spillway
8. Chute
9. Gate plateau
10. Access to powerhouse
11. The existing road
12. A pipeline for the heating of equipment in the cooling water intake station during extremely cold winter days.

HYDRO POWER PLANT CROSS-SECTION



ANNUAL ELECTRICITY PRODUCTION

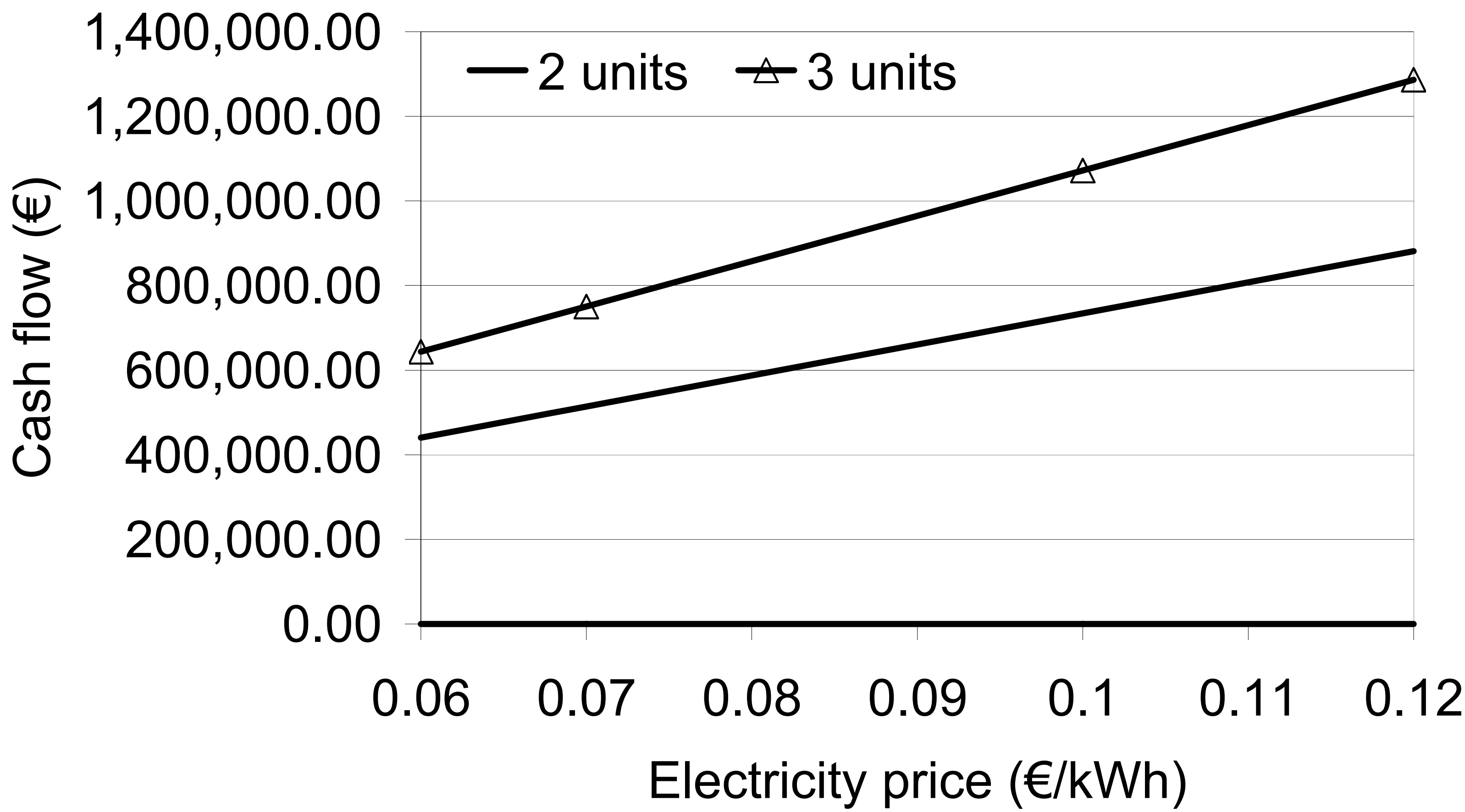
$$E_{el} = 8.76 \cdot \rho \cdot g \cdot \dot{V} \cdot \eta_{HE} \cdot \int_0^1 H(x)\,dx - \Delta E_r$$

$$H(x) = \begin{cases} H_{n,\max}, & H_n(x) > H_{n,\max} \\ H_n(x), & H_{n,\min} \le H_n(x) \le H_{n,\max} \\ 0, & H_n(x) < H_{n,\min} \end{cases}$$

ANNUAL ELECTRICITY PRODUCTION IN THE HYDRO POWER PLANT DEPENDING ON THE NUMBER OF UNITS IN OPERATION

Units of Thermal Power Plant in operation	Unit 1	Unit 2	Units 1+2	Units 1+2+3
Annual production of electricity E_{el}, (GWh/god)	3.88	3.78	7.45	10.83

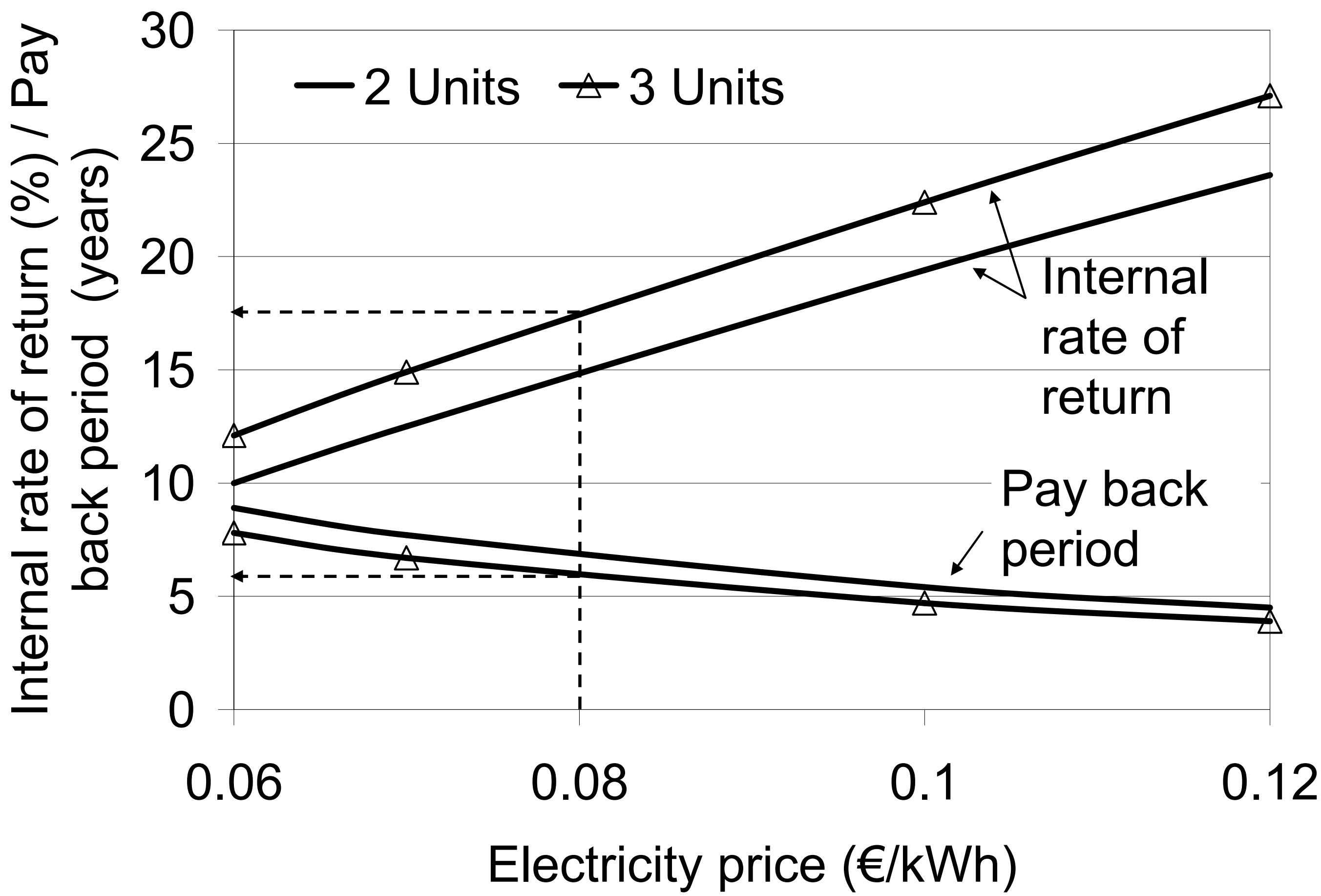
VALUE OF ANNUAL ELECTRICITY PRODUCTION IN THE HYDRO POWER PLANT THAT UTILIZES ENERGY OF THE COOLING WATER FLOW AT THE COAL-FIRED THERMAL POWER PLANT "NIKOLA TESLA B" VERSUS ELECTRICITY PRICE



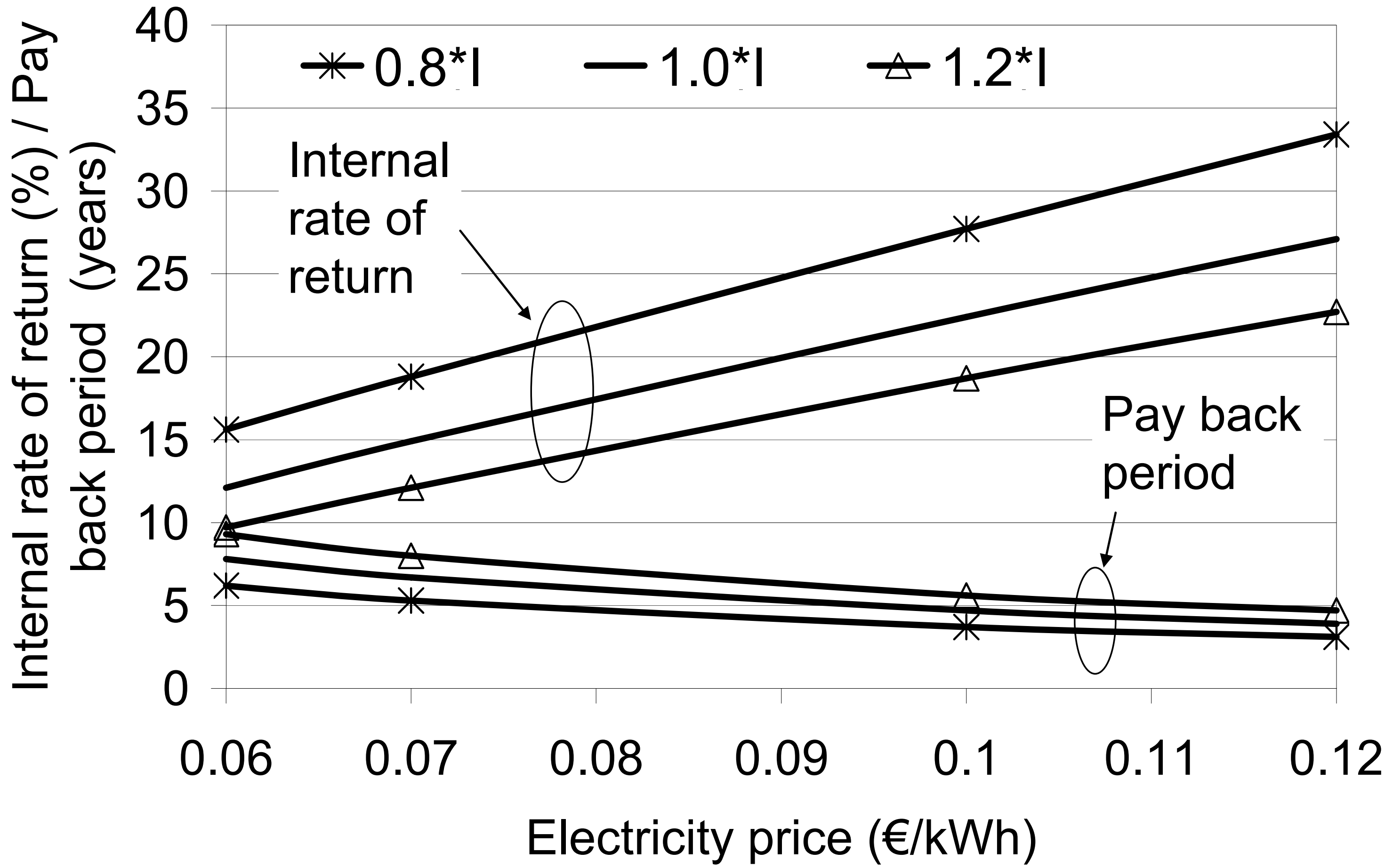
PRESENT VALUE OF COSTS

	Power per unit, P_n (kW)	Total power, zP_n (kW)	Specific cost of equipment, I'_{EM} (€/kW)	Total cost of equipment, $I_{EM}=z\, I'_{EM} P_n$ (€)	Cost of civil works, I_{CV} (€)	Total investment, I (€)	Present value of O&M costs, C_{OM} (€)	Present value of total costs C_T (€)
Two turbines, z=2	800	1600	1245	1.992.000	1.670.000	3.936.650	944.425	4.881.075
Three turbines, z=3	800	2400	1245	2.988.000	1.670.000	5.007350	1.258.600	6.265.950

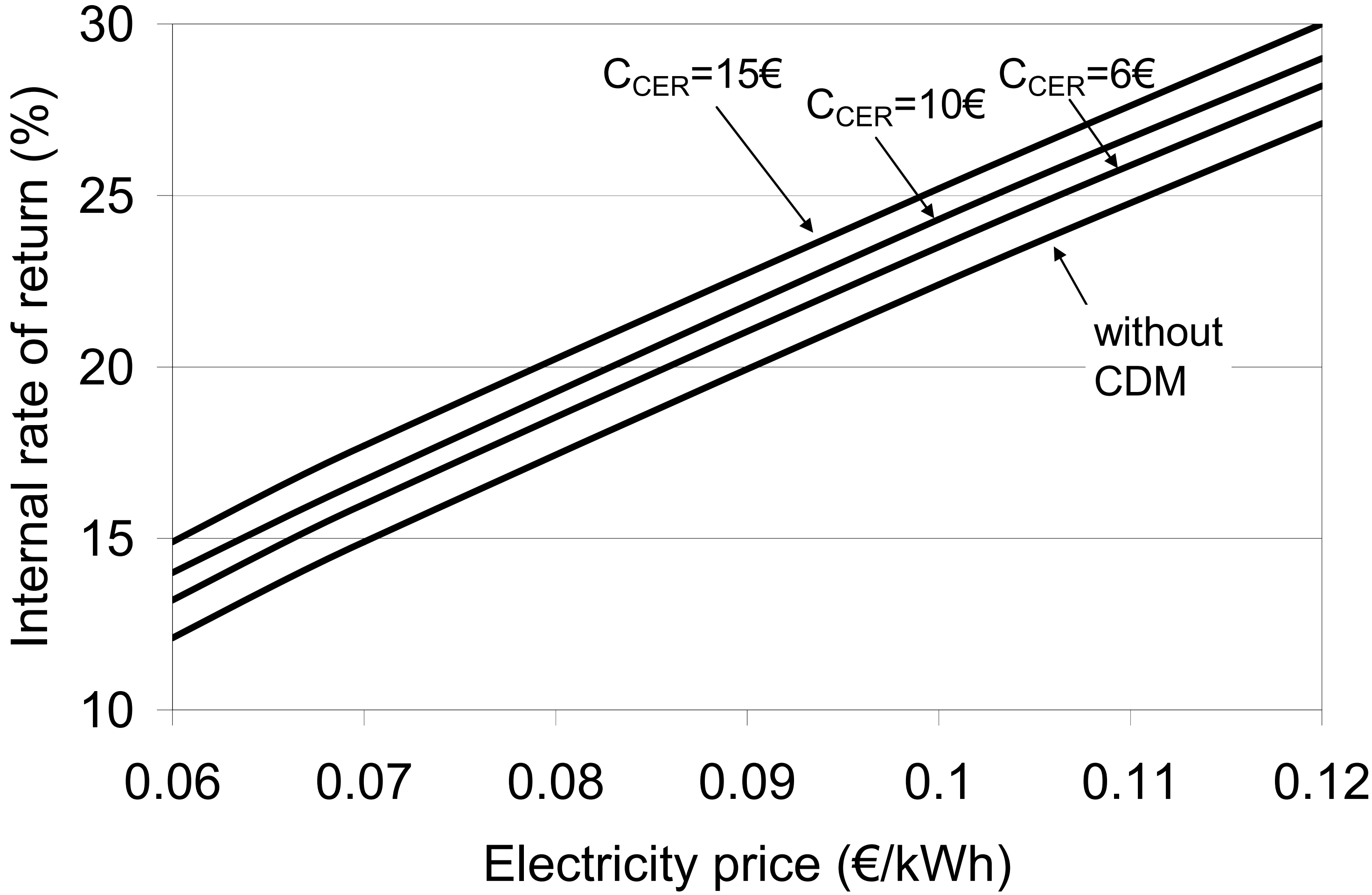
INTERNAL RATE OF RETURN AND PAY BACK PERIOD FOR THE HYDRO POWER PLANT PROJECT THAT UTILIZES ENERGY OF THE COOLING WATER FLOW AT THE COAL-FIRED THERMAL POWER PLANT "NIKOLA TESLA B"



INTERNAL RATE OF RETURN AND PAY BACK PERIOD DEPENDENCE ON THE TOTAL INVESTMENT COSTS I



INTERNAL RATE OF RETURN DEPENDENCE ON THE VALUE OF THE CERTIFIED EMISSION REDUCTION



CONCLUSION

The obtain results show that the project is economically attractive, and it can be realized with standard matured solutions of hydro turbines available at the market.