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Alpine hydropower plants renewal : synergies between flexible production and hydropeaking mitigation

Mathieu Barnoud ; Sabine Chamoun ; Pedro Manso ; Giovanni De Cesare

EPFL

Motivation

Hydropeaking is the water flow or level variations in rivers caused by hydropower exploitation. This phenomenon have negatives impacts on fauna and flora. Mitigation measures can lead to producing less and reduce production at the times that are most economically attractive. In a context where renewable energy production wishes to be increased and where operators wish to maintain their revenues, these measures are not satisfactory. This work aims to propose mitigation solution which keep production and flexibility constant or even increase them.

Methodology and indicators

Several variants and operating scenarios will be evaluated on construction cost, energy production, revenues and hydropeaking.

Hydropeaking will be mainly evaluated with the indicators I_A. It will be considered problematic when its value is higher than 1.5.

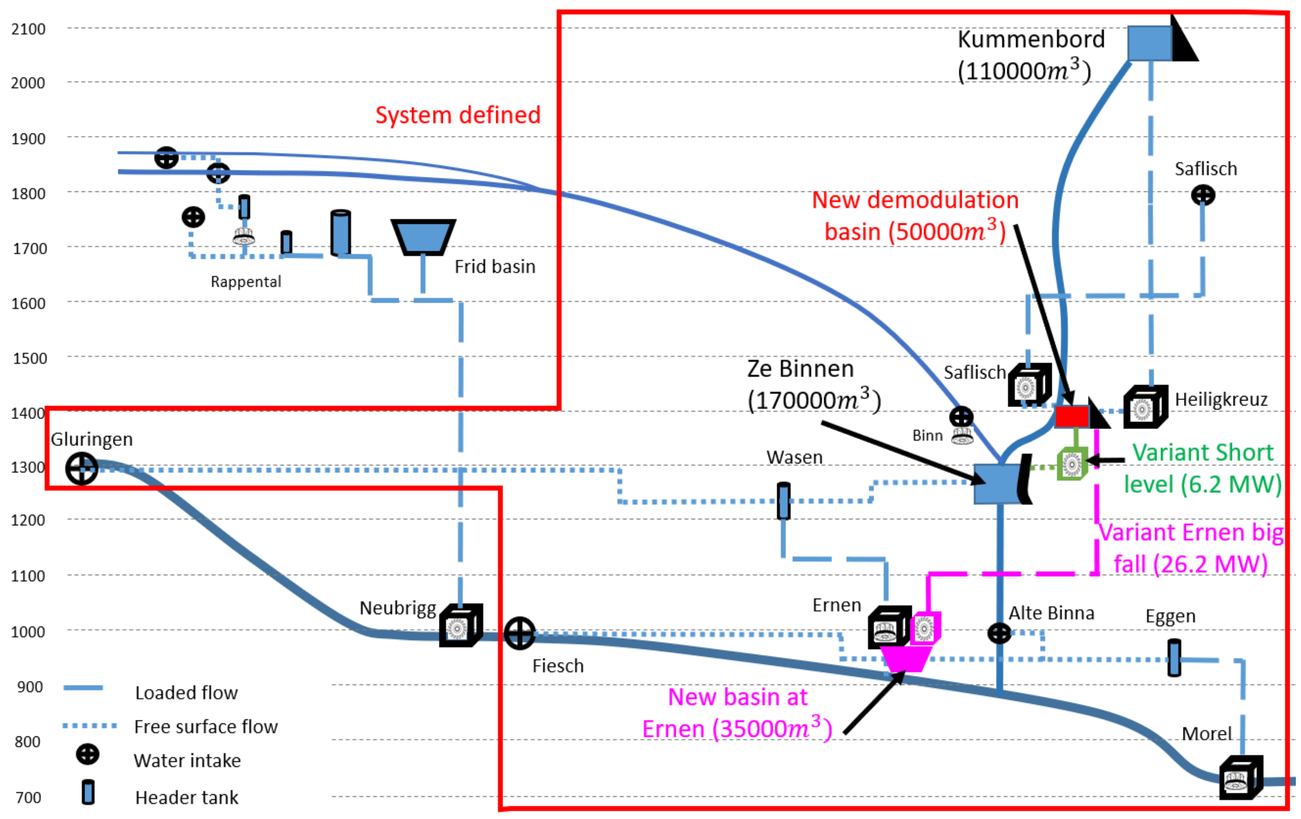
$$I_A = \frac{Q_t}{Q_{min}}$$

Q_t : The hydropower plant exploitation discharge at time t

Q_{min} : The minimum discharge in the river on the period studied

Studied case

The case study is composed of 5 hydropower plants located in the Upper-Rhône Basin. Among these installations, Heiligkreuz is subject to an order of hydropeaking sanitation. **Hydropeaking have been detected between Heiligkreuz and Ze Binnen and also downstream Mörel power plant.** Two variant were preselectioned and three operating scenario were studied.



Scenario Business as usual "BAU": The power plants operating modes try to be as close as possible to the reference state operating modes. The new plant operates in a similar way to Heiligkreuz one.

Scenario "Economic": The power plants use the maximum available volume when the price exceeds a threshold. The rest of the time, they operate on a run-of-river basis.

Scenario "Null Hydropeaking": The operating modes are similar to those of the "economic" scenario, but those which still causing hydropeaking are adapted in order to eliminate it completely.

Figure 1 : Système and variants studied

Hydropeaking in Heiligkreuz river section

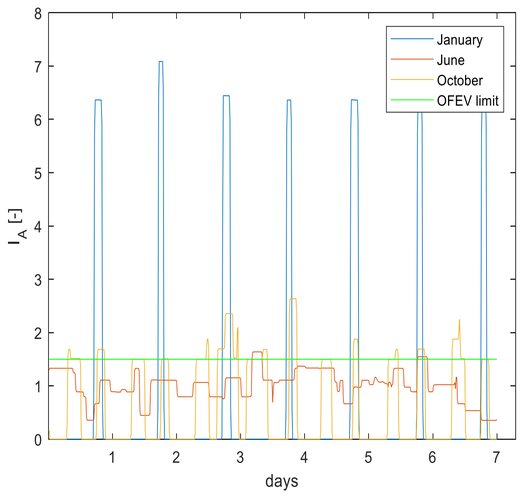


Figure 2 : I_A at the reference state

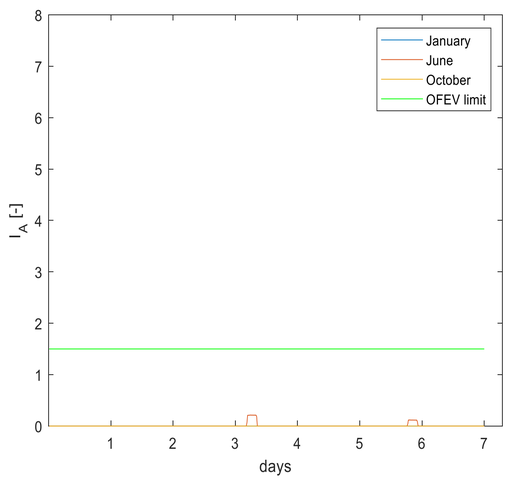


Figure 3 : I_A for both variants and all scenarios

Hydropeaking in Mörel river section

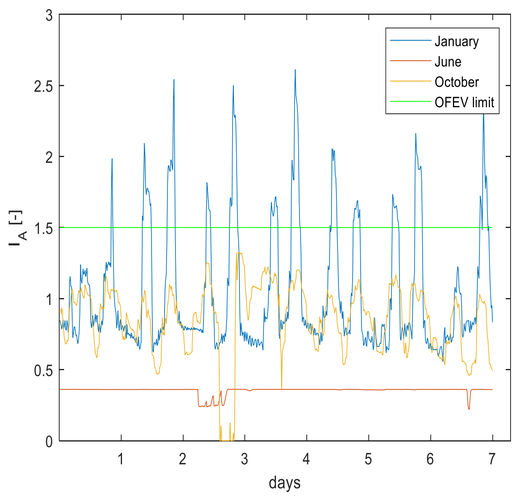


Figure 4 : I_A at the reference state

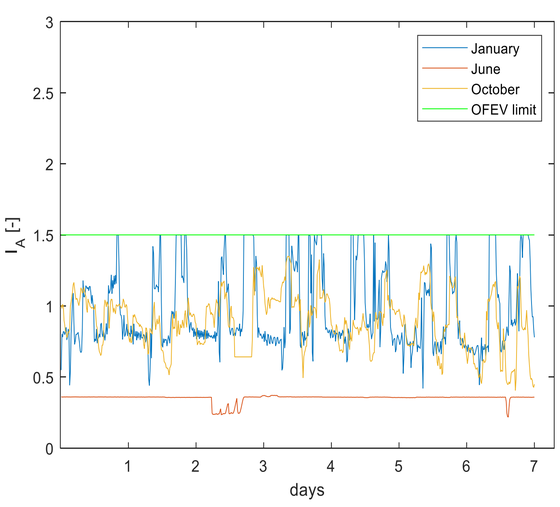


Figure 5 : I_A for the scenario null hydropeaking

Production and revenues

Table 1 : Production ($\Delta E[GWh/year]$) and revenues ($\Delta R[Mio\ CHF/year]$) differences with reference state(E_i, R_i)

Variants	Scenarios	ΔE	$\Delta E/E_i[\%]$	ΔR	$\Delta R/R_i[\%]$
Short level	BAU	10.4	2.31	0.41	2.23
	Economic	33.8	7.49	1.42	7.67
	Null Hydropeaking	23.6	5.23	0.84	4.55
Ernen Big Fall	BAU	24.4	5.39	0.94	5.07
	Economic	44.5	9.85	1.71	9.27
	Null Hydropeaking	35.2	7.80	1.19	6.46

Discussion

Variants studied allow to improve production and to mitigate hydropeaking on Heiligkreuz section but replace river section with hydropeaking by river section with residual flow. Ecological benefits induced by this replacement are not proved yet. The scenario "Null Hydropeaking" allow to delete hydropeaking on Mörel river section but cause a flexibility loss showed by a revenues reduction.

Conclusion

Based on a construction cost estimation, the short level variant appears about 6 time cheaper than the Ernen big fall variant. Solution with the smaller spatial scale and impact on the system is recommended.

References

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