

the third life of the tavagnasco hydropower plant the chance of an ultimate upgrade



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the chance of an ultimate upgrade

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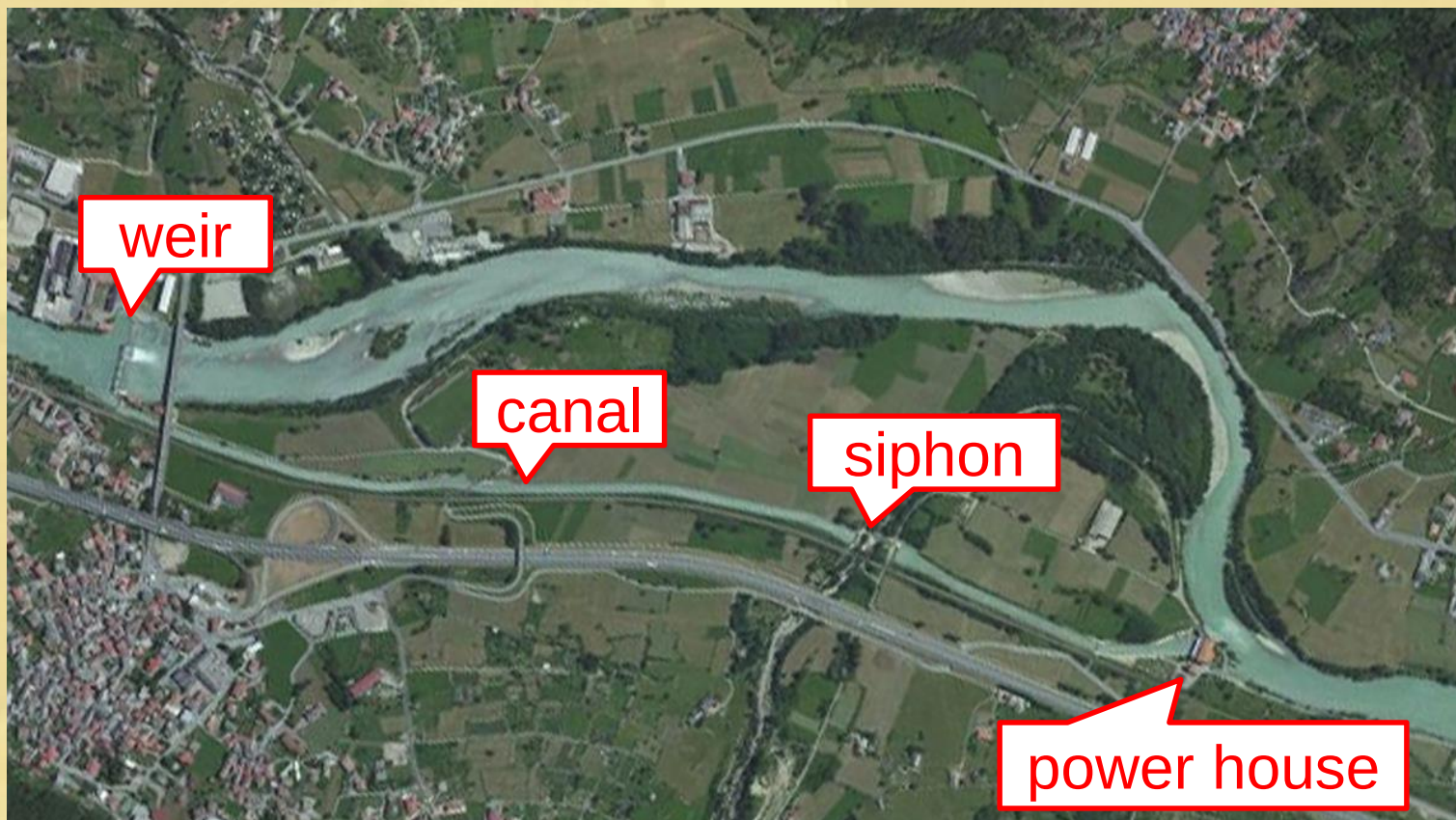
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1. the power plant and its unexpected history



1. the power plant and its unexpected history

- erected in 1925
- designed by Gaetano Ganassini, professor of hydraulics and headmaster of the faculty of engineering at Politecnico in Milan
- remained unexpectedly in the hands of the designer and belongs even now to his family
- was formerly planned and erected with two Kaplan units
- was upgraded in 1960 by adding a third Kaplan, that came from another hydropower plant

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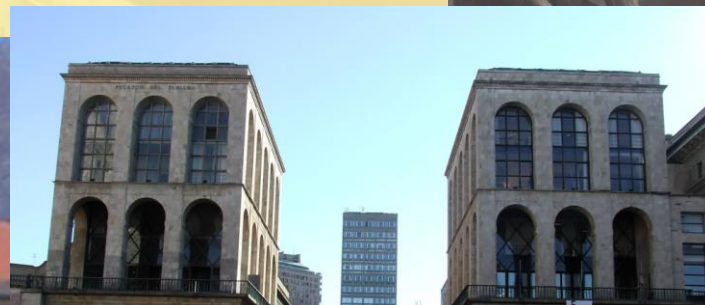
1. the power plant and its unexpected history



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1. the power plant and its unexpected history

the remarkable architectural design
(probably by the famous architect Piero Portaluppi)



2. the former hydraulics of the canal

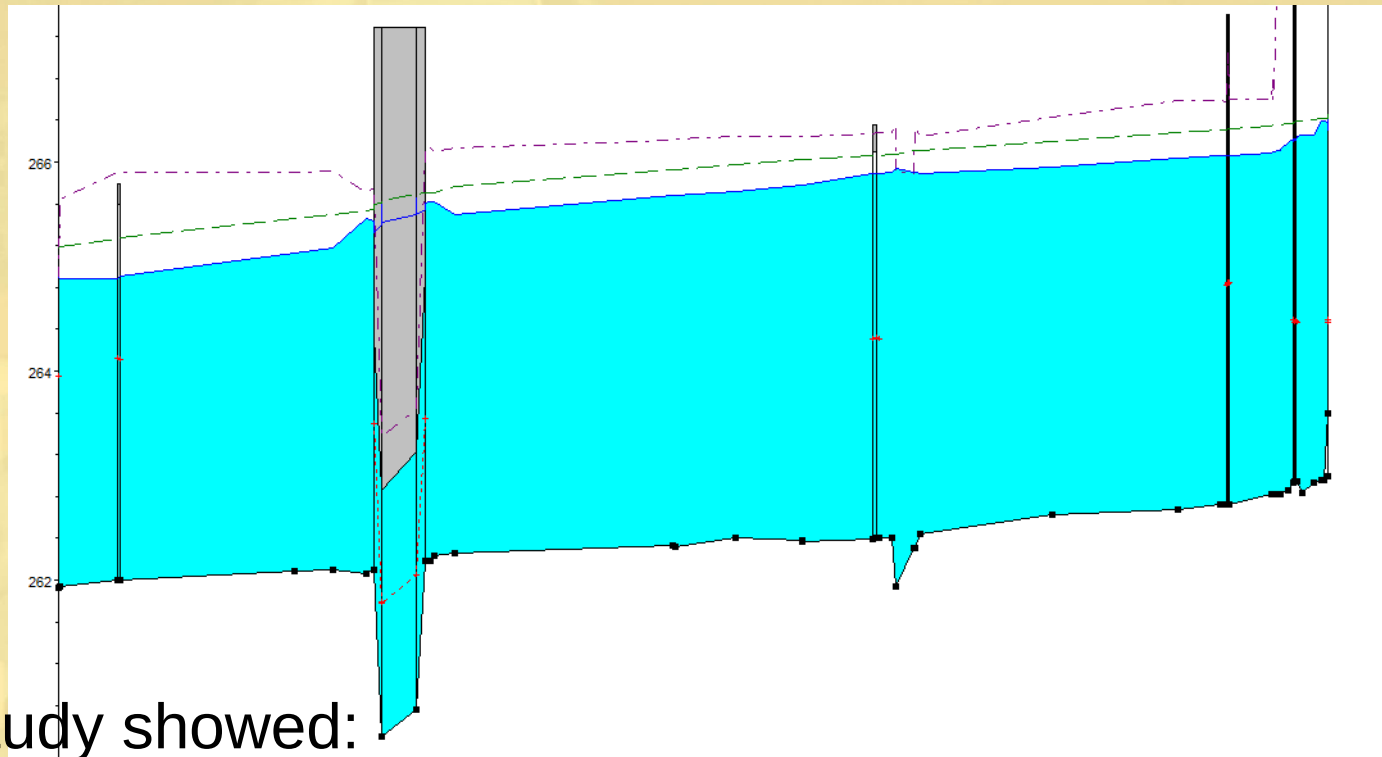
as designers of the refurbishment of the plant, we were expected only to specify the replacement of the powerhouse machinery

we took into account also the hydraulics of the waterways

the head losses in the headrace canal were rather high: that could reveal an inefficiency

the water surface slope was about 0.1%, almost twice as much the slope of the canal bottom

2. the former hydraulics of the canal



the hydraulic study showed:

- a water velocity up to 2.9 m/s
- the velocity tended to grow approaching the power house

2. the former hydraulics of the canal

quite unusual, but not completely surprising!

- the plant was formerly designed for a maximum flow rate of 40 m³/s and gradually upgraded to 75 m³/s
- according to the original design, the maximum velocity should have been 1.8 m/s

the spillway at the forebay was insufficient: a sudden shutdown of the powerhouse increased the water level by about 80 cm

last, but not least: the canal passed under a stream by means of a siphon, with further head losses

there was certainly room for improvement!

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2. the former hydraulics of the canal



3. the way to the upgrade

we gave up the idea of increasing the maximum flow rate:

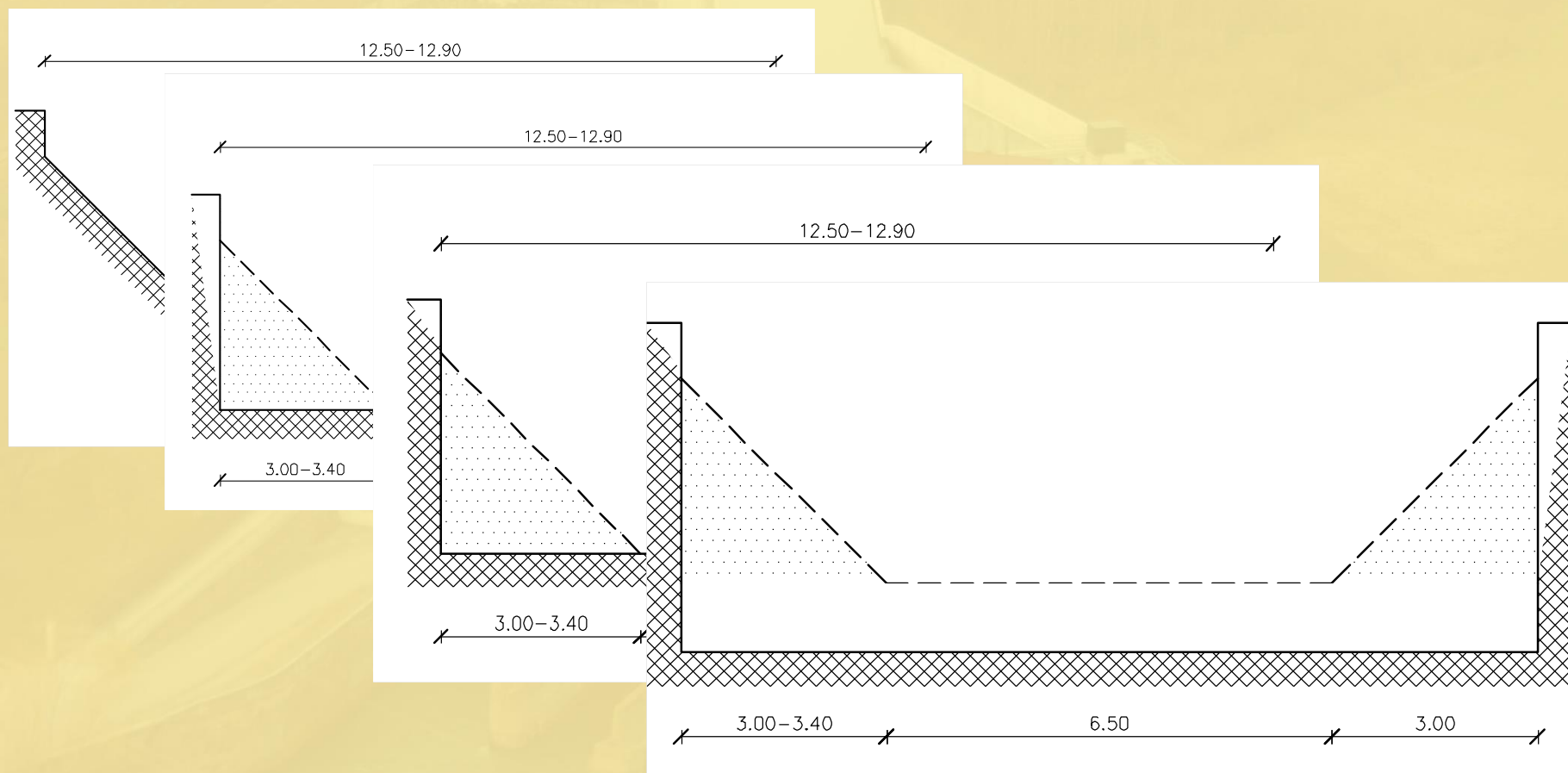
- the velocity was already very high
- it would have needed a significant modification of the water concession, with an extension of the permit process

our goal was to improve the hydraulic condition in the canal in order to reduce the head losses

we modeled different ways to reshape the canal and compared costs and benefits of every solution

3. the way to the upgrade

the different solutions to enlarge the section



3. the way to the upgrade

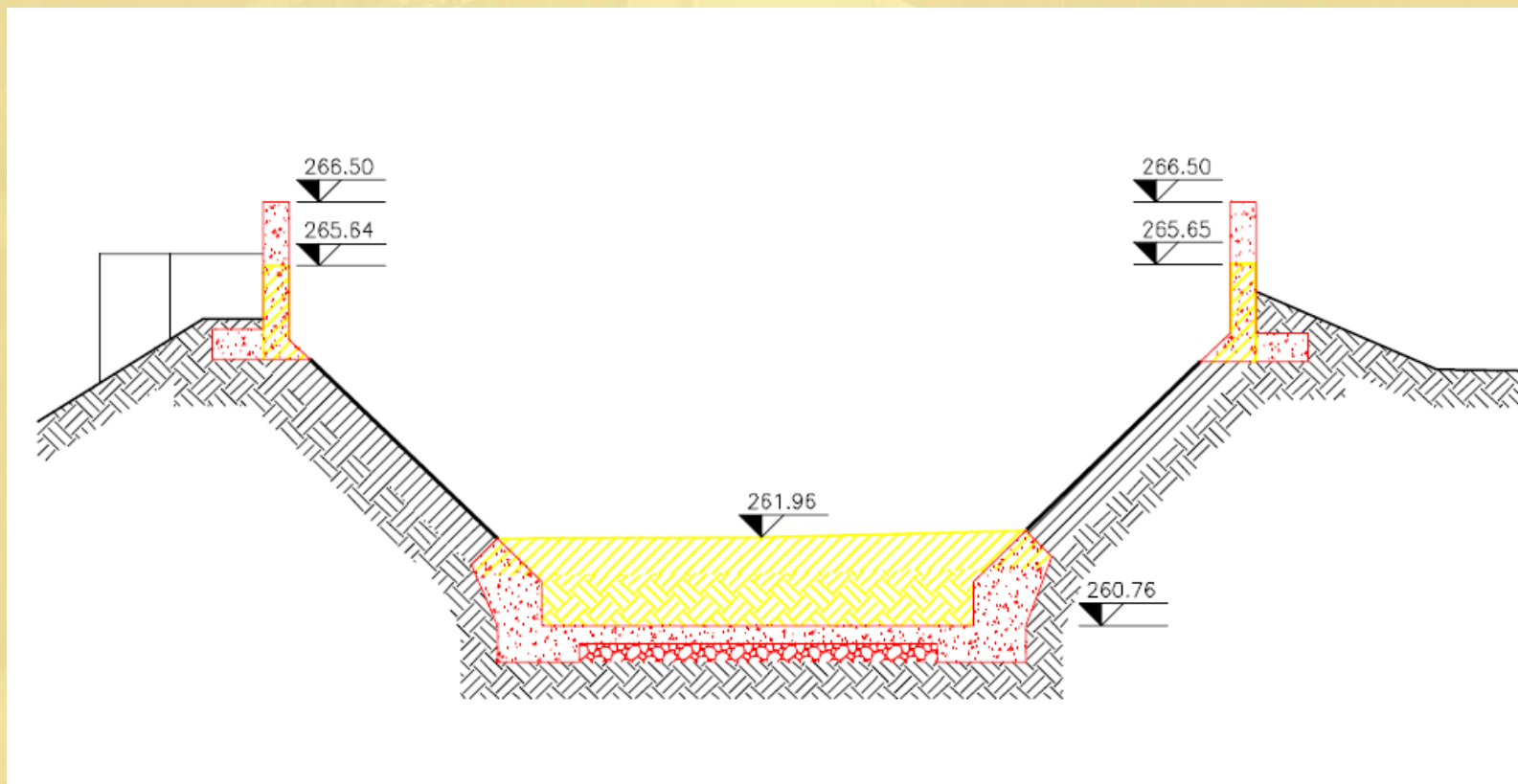
the best choice in this case was to keep the trapezoid shape:

- that led to a strong reduction of the head losses in the canal without a cost explosion
- the higher top walls alone strongly improved the hydraulic performance of the canal
- the deepening of the bottom completed the work
- the safest solution from the geotechnical point of view (very important: a railway runs along the canal!)

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3. the way to the upgrade

the new section of the canal



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3. the way to the upgrade

the section of the canal before.... and after!



3. the way to the upgrade

an apparently moderate enlargement of the cross-section affects impressively the hydraulics of the canal and strongly reduces the head losses

	before	after
maximum stream velocity	2.7 m/s	1.6 m/s
flow area (with maximum velocity)	26.8 m ²	45.6 m ²
maximum head losses	1.75 m	0.65 m

3. the way to the upgrade

but we couldn't have gained the plant enhancement without improving the hydraulic safety of the canal

- the spillway at the forebay was already inadequate for the maximum flow
- the increase of the water level wouldn't be easy to obtain with the formerly overstated freeboards

the forebay was quite completely rebuilt and a new flap gate was introduced

the closing time of the new turbines had anyway to be extended (about 30 s, divided into two stages, compared to the 6 s of the old ones)

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3. the way to the upgrade



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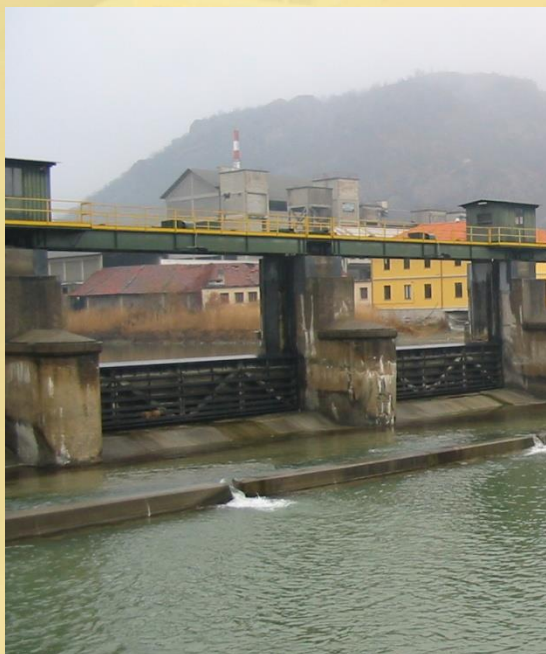
4. the works

the replacements of the units aimed also at exploiting the higher head available



4. the works

- new gates at the weir
- maintenance of the weir and elevation of the control bridge (raising and reinforcing piers and foundation)



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4. the works

a fish-pass designed for a discharged flow up to $2 \text{ m}^3/\text{s}$



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4. the works

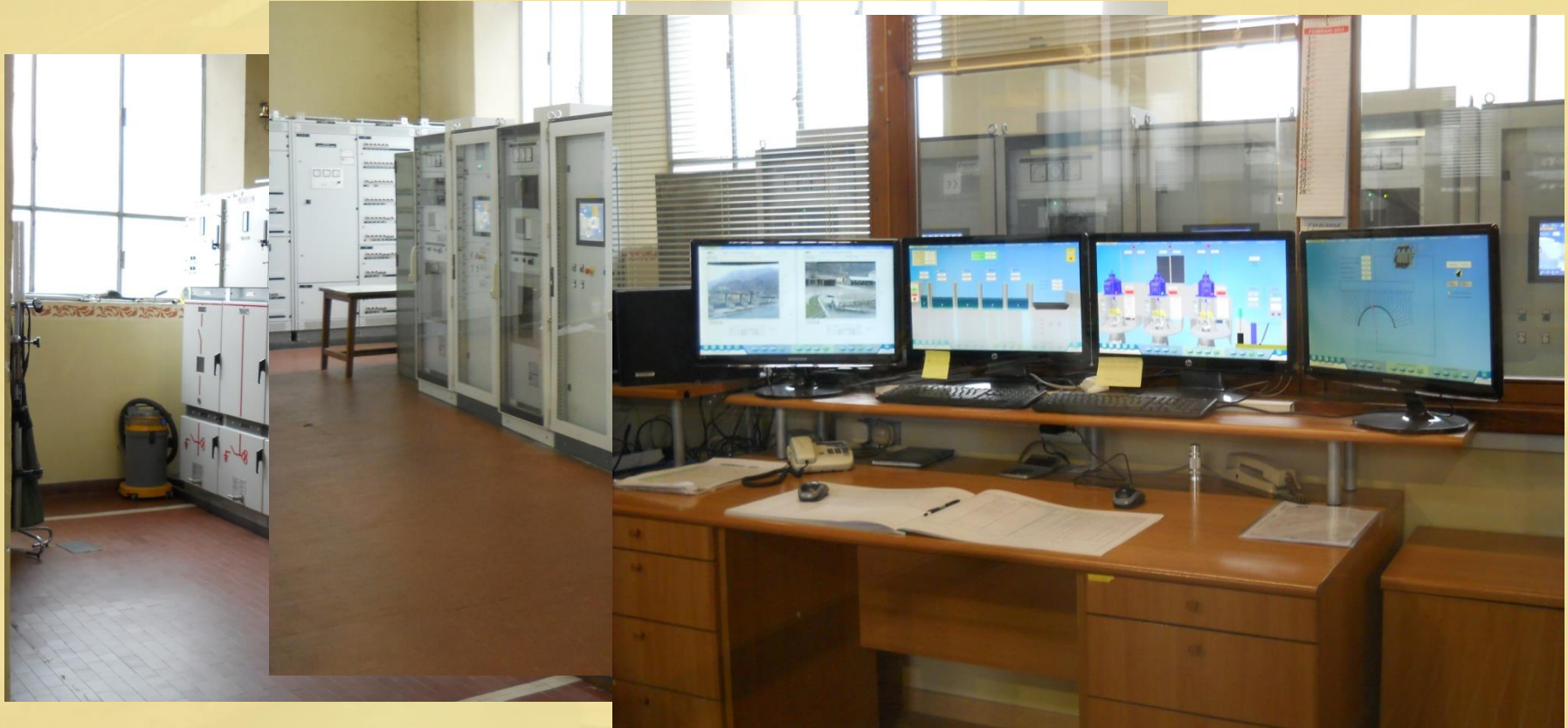
new trash racks and gates at the forebay



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4. the works

- new low and medium voltage electric plants
- a new automation and remote control system



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4. the works

a new transformer and new circuit breakers at the high voltage grid connection



this results in a completely refurbished plant that can last and effectively operate for decades!

5. costs and benefits

work		cost (M€)
weir and fish pass		2.18
canal		4.83
forebay		2.56
power house machinery		10.73
engineering		1.06
total cost		21.37
unit cost	M€/MW	2.37
	€/kWh	486

the unit cost isn't high, related to the works extension
(all the parts of the plant were involved) ...

5. costs and benefits

... and to the benefits

	before	after
rated flow	72 m ³ /s	72 m ³ /s
average environmental flow-rate	10.7 m ³ /s	19.4 m ³ /s
installed capacity	7 MW	9 MW
expected annual production	40 GWh	44 GWh
avoided annual emission of greenhouse gases	29 000 t	32 000 t
annual turnover (green certificates)	-	3.40 M€
annual turnover (additional energy sale)	-	0.24 M€

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short recap

we were expected only to specify the replacement of the unit

a significant upgrade was gained by investigating the hydraulics of the canal

we carried out a complete refurbishment of the plant, with an enhancement of the hydraulic safety of the canal

the result is indeed positive, regarding both the turnover and the environment

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thank you!

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