RENEXPO®
INTERHYDRO

PLANTS EXPLOITING RESERVED FLOW

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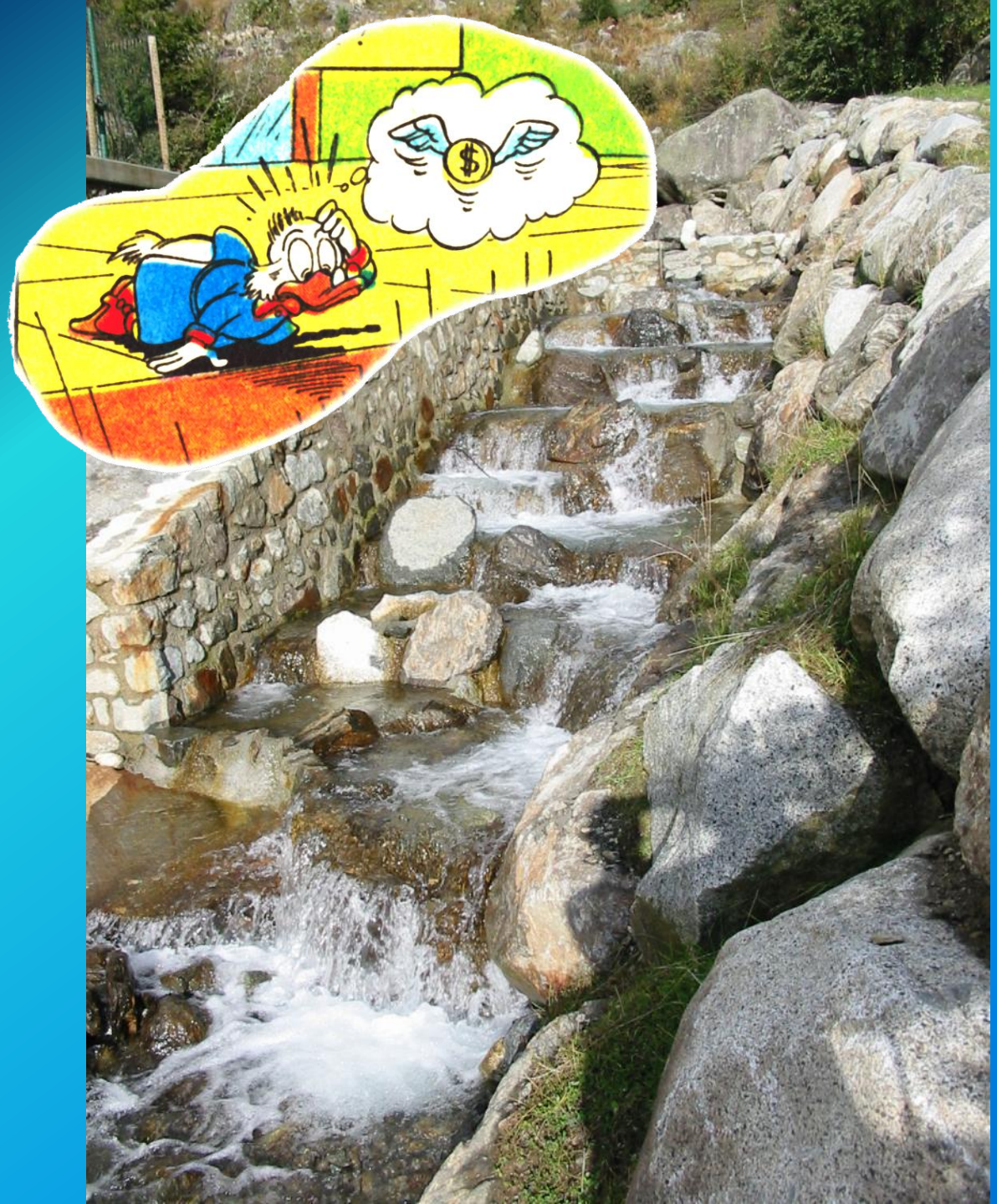


What do I need for hydro energy production?

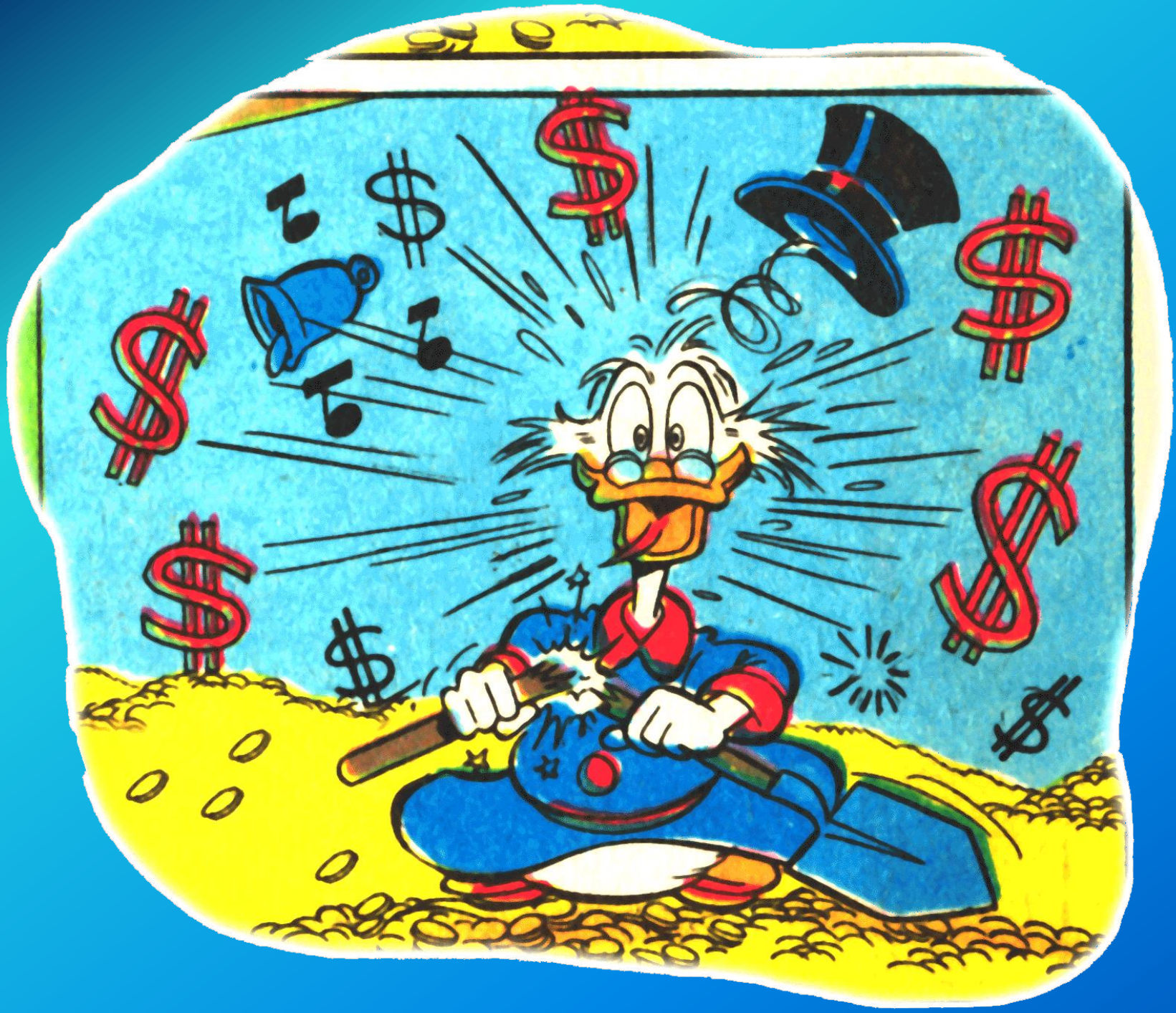
Flow

= Reserved flow – fish passage flow rate

Head

= WL difference at the dam or weir

To exploit the residual ***Flow*** to produce hydroelectric energy if a ***Head*** is available



PRESENT VS. PAST SITUATION

- ✓First experimental applications on both high and low heads
- ✓Nowadays mainly low and very low head schemes, exploiting the reserved flow released from existing diversion weirs

High head
Santa Giustina Dam

Medium head
Mollaro Dam

Low head
Chievo Dam

MOST REPRESENTATIVE PROJECTS ON THE RESERVED FLOW

✓Recent plants designed by STUDIO FROSIO in Italy

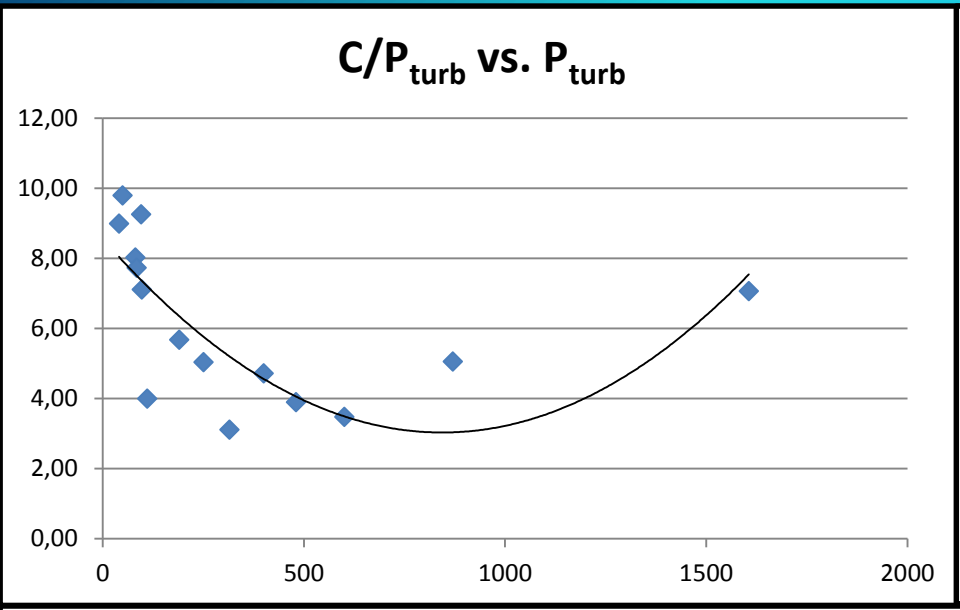
	Q_{max}	Q_{med}	H_g	P_{turb}	P_{gen}	Type gen	n_{turb}	n_{gen}
	m^3/s	m^3/s	m	kW	kW		rpm	rpm
Turano	0,100	0,100	49,61	40	37	Async	1.010	1.510
Scarico Casnigo	1,64	1,64	3,05	49	47	Async	292	1.012
Casnigo	1,58	1,58	5,20	81	77	Async	466	1.006
Fonderia	2,45	2,45	3,50	84	90	Async	301	1.006
Parre	3,00	1,89	4,30	95	98	Async	322	1.006
Prato Mele	2,46	1,90	4,70	97	95	Async	366	1.006
Monte Argento	2,000	2,000	6,25	110	106	Async	400	1000
Esine	4,50	3,10	4,20	190	180	PMG	333	333
Santa Maria Magale	5,000	5,000	4,29	250	234	Async	253	750
Palosco	5,88	3,74	5,80	315	285	Sync	-	-
Urago	12,00	10,21	3,50	400	360	Sync	-	-
Capriolo	10,00	4,13	5,90	480	480	PMG	272	272
Roggia Vetra	11,00	6,54	6,30	600	680	PMG	333	333
Carema	24,00	17,22	4,00	870	1.250	PMG	150	150
S. Caterina	40,00	36,45	4,50	1.606	1.285	PMG	176	176

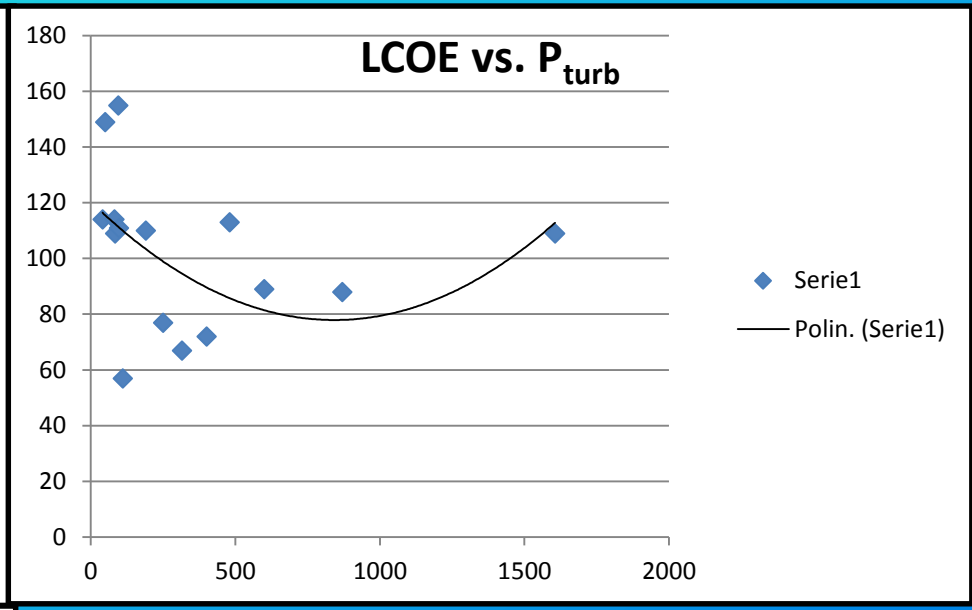
MOST REPRESENTATIVE PROJECTS ON THE RESERVED FLOW

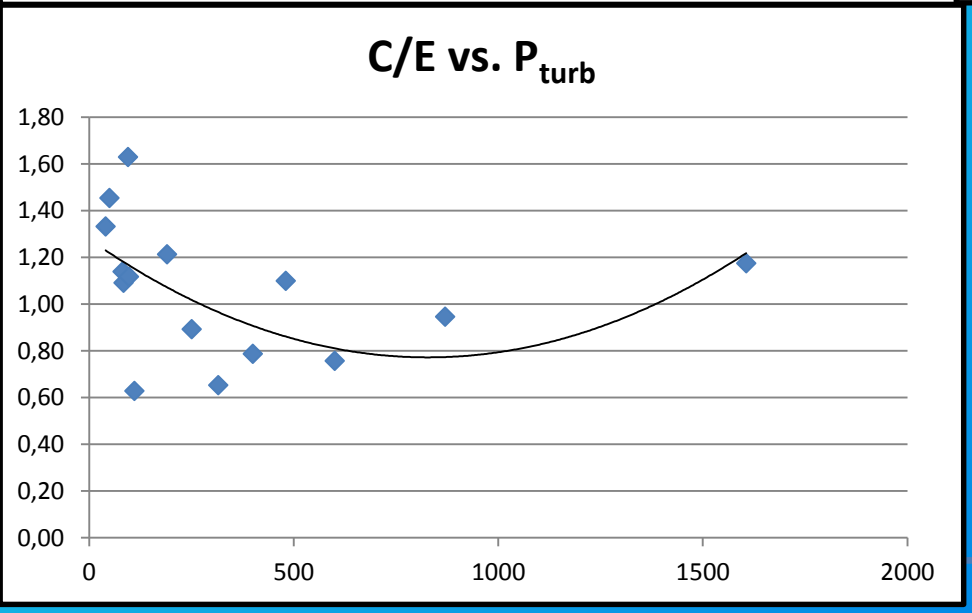
✓Recent plants designed by STUDIO FROSIO in Italy

	P_{turb}	E	C	C/E	C/P_{turb}	LCOE
	kW	MWh/yr	k€	k€/MWh	k€/kW	€/MWh
Turano	40	270	360	1,33	9,00	114
Scarico Casnigo	49	330	480	1,45	9,80	149
Casnigo	81	570	650	1,14	8,02	114
Fonderia	84	595	650	1,09	7,74	109
Parre	95	540	880	1,63	9,26	155
Prato Mele	97	617	690	1,12	7,11	111
Monte Argento	110	700	440	0,63	4,00	57
Esine	190	890	1.080	1,21	5,68	110
Santa Maria Magale	250	1410	1.260	0,89	5,04	77
Palosco	315	1.500	980	0,65	3,11	67
Urago	400	2.400	1.890	0,79	4,73	72
Capriolo	480	1.700	1.870	1,10	3,90	113
Roggia Vetra	600	2.760	2.090	0,76	3,48	89
Carema	870	4.650	4.400	0,95	5,06	88
S. Caterina	1.606	9.660	11.350	1,17	7,07	109

SEARCHING FOR CORRELATION (WHICH DOESN'T MEAN CAUSATION….)







DESIGN AND OPERATION ISSUES

- **INTERACTION WITH THE EXISTING WEIR AND PLANT**
  - Downstream water level variations
  - Upstream water level regulation
  - Limitation of the diverted flow rate
  - Interaction with fish passages
  - Positioning and protection from floods
  - Environmental and visual impact reduction

SUCCESSFUL DESIGN SOLUTIONS

✓Permanent Magnet Generators (PMG):

☺Compact: smaller dimensions than conventional generators

☺Direct coupling of turbine and generator: higher efficiencies and lower maintenance than gearboxes or belt driven generators

☹Expensive

☹Capacitors needed for power factor control

SUCCESSFUL DESIGN SOLUTIONS

✓Belt Driven Generators (BDG):

☺Cheap and simple

☺Well proven technology

☹Limitation in the output range of operation (< 500 kW)

☹Lower efficiencies than direct coupling

☹Cheaper and faster maintenance if compared with gearboxes

DESIGN AND OPERATION ISSUES

✓Downstream water level variations

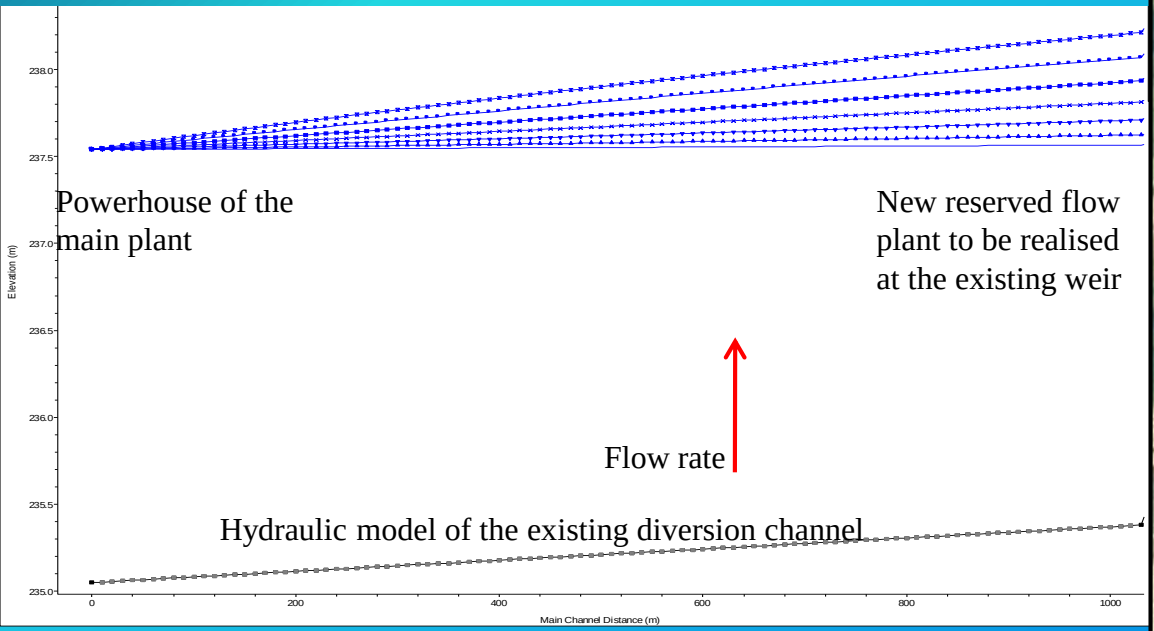
Low flow downstream water level

High flow downstream water level

Head variation ⟶ Adjustable wicket gates

DESIGN AND OPERATION ISSUES

- ✓Upstream water level regulation
- ✓Limitation of the diverted flow rate



Head variation ⟶ Adjustable wicket gates

DESIGN AND OPERATION ISSUES

✓Interaction with fish passages

CASNIGO SCARICO

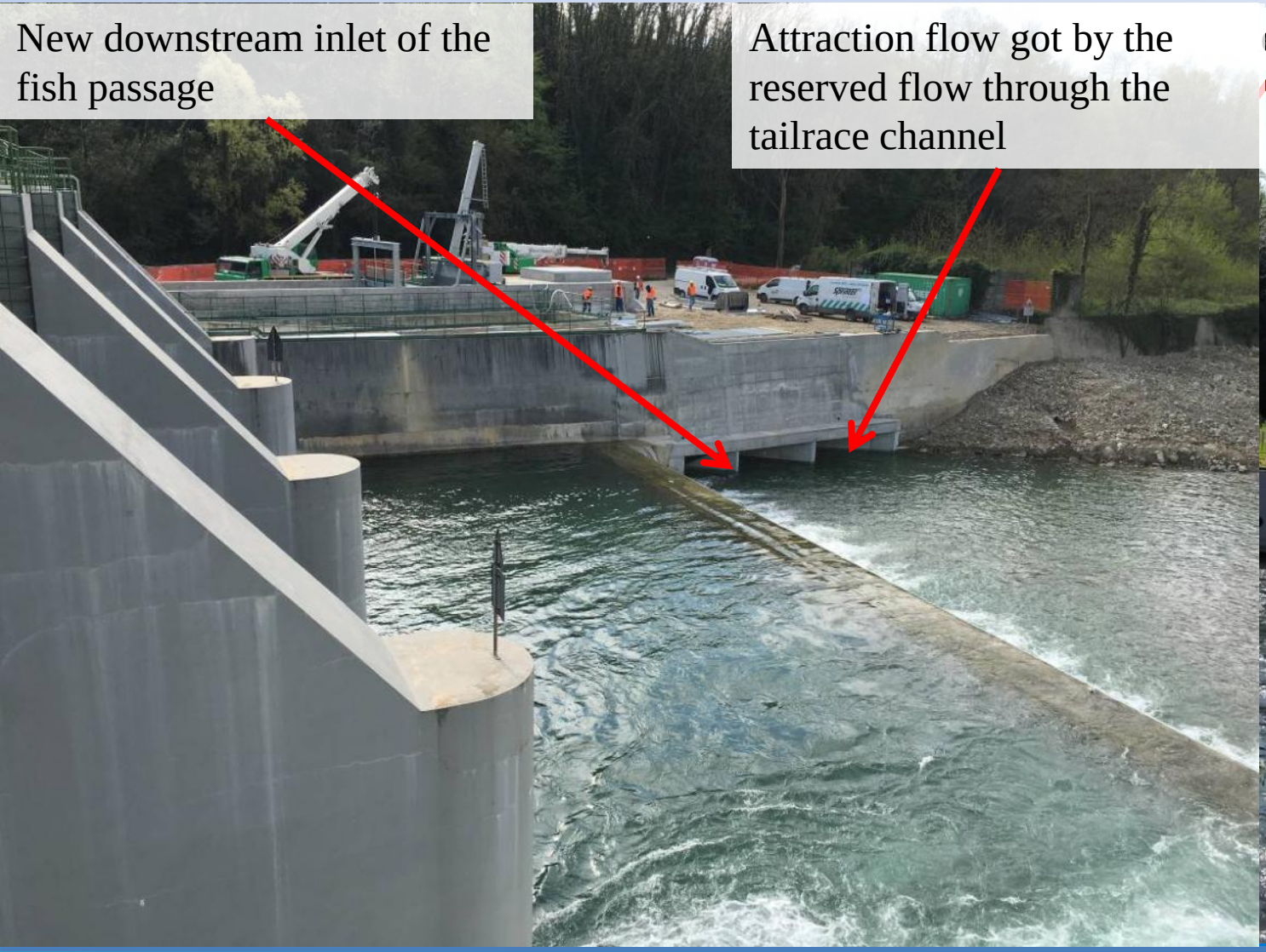
DESIGN AND OPERATION ISSUES

✓Interaction with fish passages

New downstream inlet of the fish passage

Attraction flow got by the reserved flow through the tailrace channel

et of the fish passage



Environmental and visual impact reduction

Before

After

Before

After

Environmental and visual impact reduction

Environmental and visual impact reduction

Choice of electromechanical equipment and plant layout

Double regulated Kaplan turbine coupled with PMG

DESIGN AND OPERATION ISSUES

✓Choice of electromechanical equipment and plant layout

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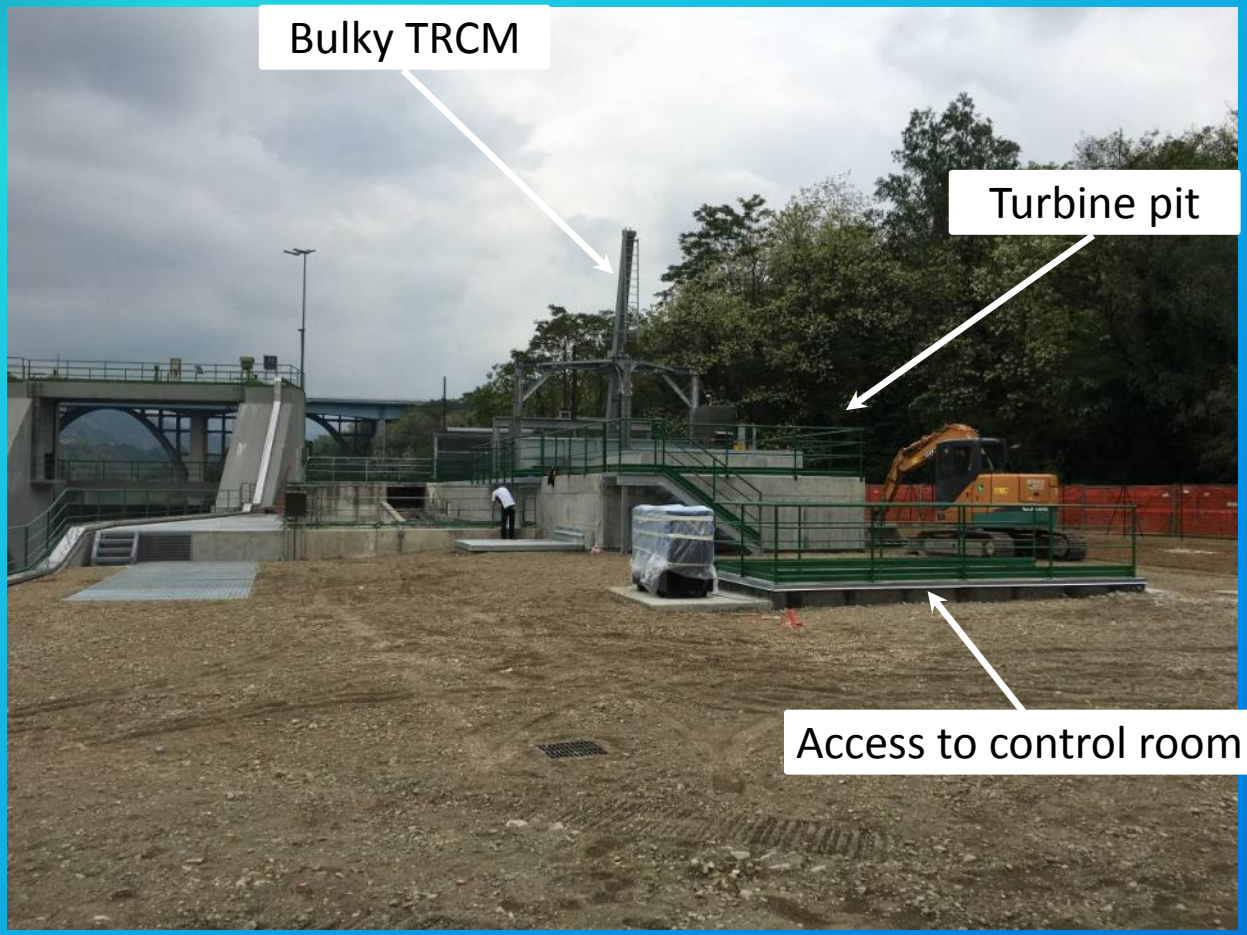
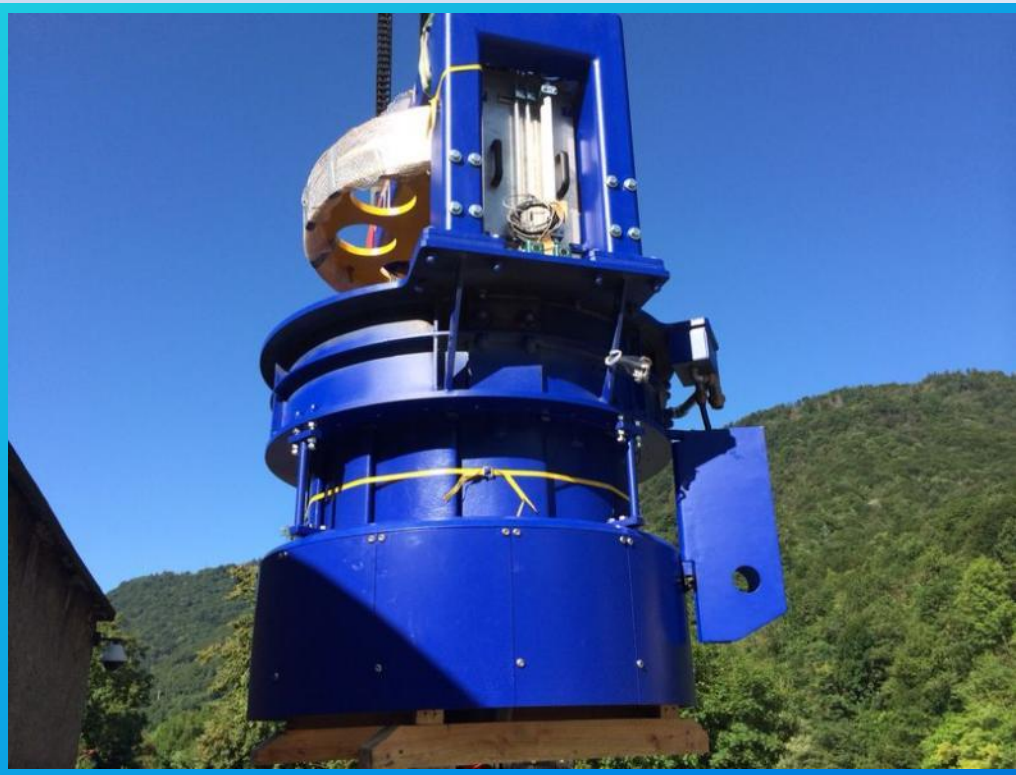


Double regulated Kaplan turbine coupled with PMG

PROBLEMI DI PROGETTO E D'ESERCIZIO

✓Scelta delle macchine e layout dell'impianto

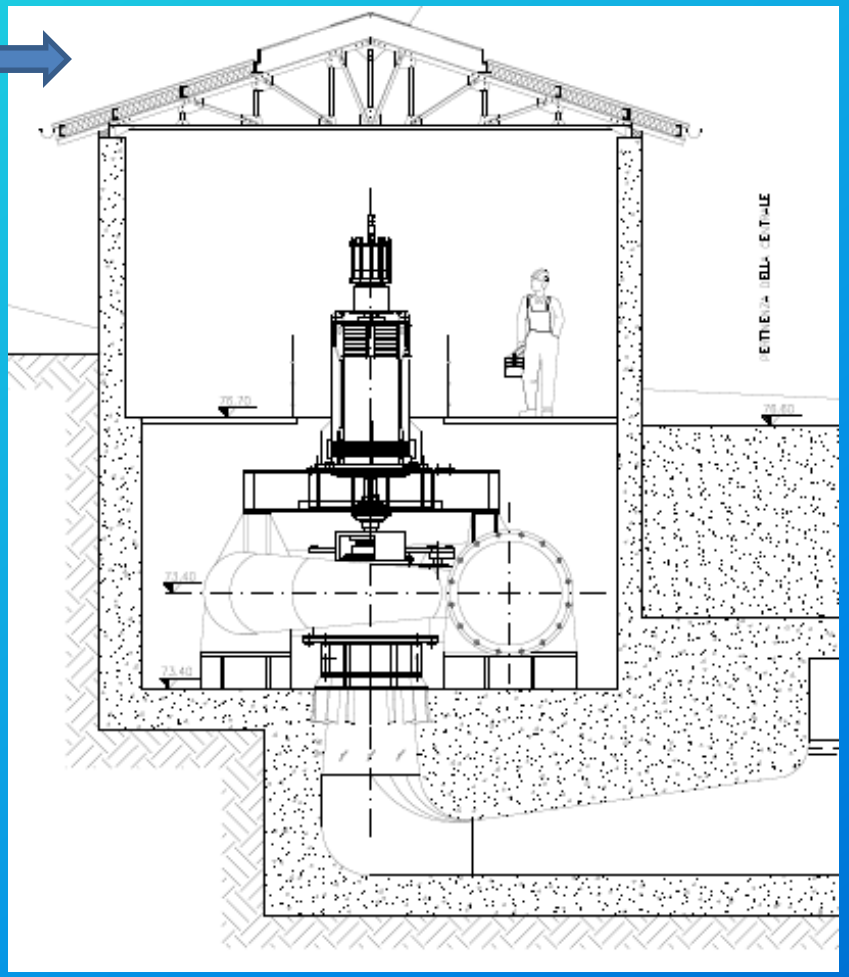


Kaplan doppia regolazione con trasmissione a cinghia

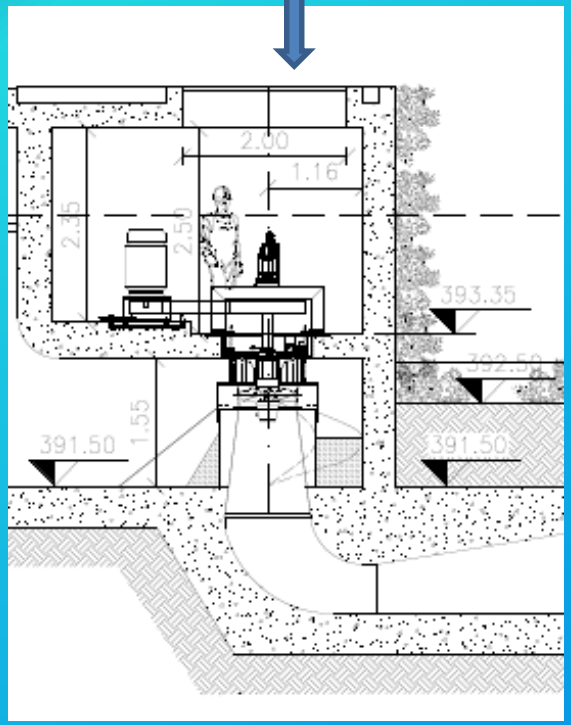
PROBLEMI DI PROGETTO E D'ESERCIZIO

✓Scelta delle macchine e layout dell'impianto

✓Soluzione convenzionale



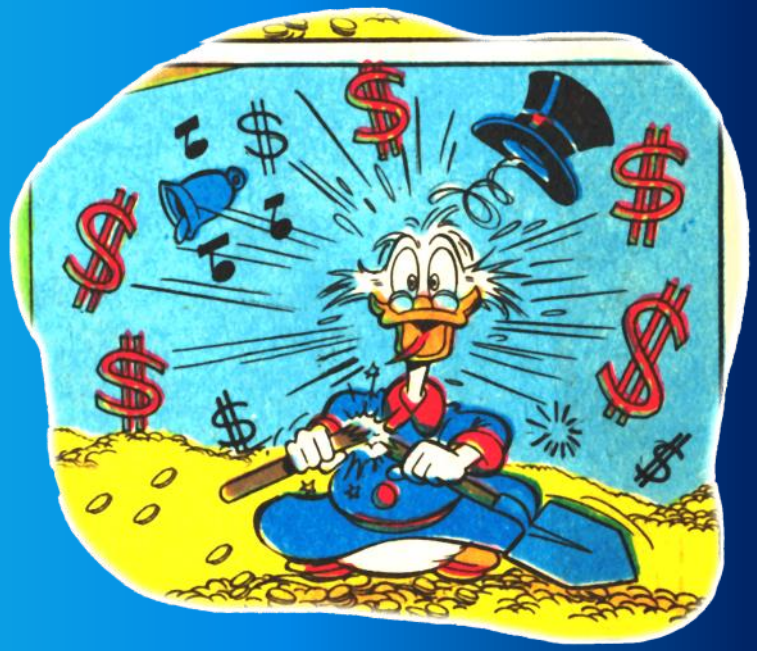
✓Soluzione BDG



Kaplan doppia regolazione con trasmissione a cinghia

Authorization and tariff frame

- ✓No Environmental Impact Assessment
- ✓Priority or direct access to incentive system
- ✓No hydrological uncertainties



FUTURE EXPLOITATION PERSPECTIVES

✓… who knows?

THE END

STUDIO FROSIO