

DIAGONAL-TURBINE

A DOUBLE REGULATED MEDIUM HEAD HYDROPOWER SOLUTION

GEPPERT IN A GLANCE EST. 1896

INSTALLED UNITS >3000

ANNUAL TURN OVER



ANNUAL PRODUCTION

>25 units



OUR SOLUTIONS:

- EPC Contracting
- Water to Wire Solutions
- Hydropower Turbines
- Refurbishment
- After Sales Service
- Automation Systems
- Hydropower Cube

TURBINE TYPES:





Pelton turbine

Up to 30 MW Up to 1000 m

Francis turbine Up to 30 MW Up to 250 m

Diagonal turbine Up to 5 MW Up to 100 m

Cross-flow turbine Up to 2 MW Up to 100 m

Kaplan turbine Up to 10 MW Up to 40 m

DIAGONAL-TURBINE:





- Double regulated
- Heads up to 100 m
- Discharges up to 10 m³/s
- Power outputs up to 5 MW

FIRST DESIGNS FROM 1950S:

- P. Dériaz developed first Diagonal turbines around 60 years ago.(due to that reason it is also called Dériaz-Turbine)
- First executed hydro power station: pump storage power plant Niagara with 6 units of 35 MW each, H = 35 m
- Biggest executed hydro power station with up to 700 MW per unit
- Since 1980s only a few large hydro power stations with this turbine type were executed, which are located in Japan, Russia and Scandinavia



TECHNICAL:

- Setting and mode of functioning corresponds to a Francis turbine
- Wicket gate and spiral casing are quite similar to ones of Francis turbines
- Additional to adjustable guide vanes, the diagonal turbine has adjustable runner blades to reach maximum possible efficiencies.
- Runner blades with spherical shape on outer diameter
- Adjusting device is installed inside the runner hub, similar to Kaplan turbines



AREAS OF APPLICATION:

- Implementation in a spiral casing or as a shaft power plant in an open or closed water chamber
- Horizonal or vertical direction
- For maximum efficiency adjustable runner blades and guide vanes are recommended
- n_q 50 80
- Net head up to 100 m (limited by strength of the runner blades)
- Implementation in existing Francis spiral casings possible





SERVICE & MAINTENANCE COMPARED TO FRANCIS TURBINES

- Slightly increased service and maintenance costs due to movable parts inside the runner
- Implemented cleaning function of the runner by short term adjustment of the wicket gate and runner blades
- No additional consumables required

Pictures: Diagonal turbines under maintenance

APPLICATION ADVANTAGE FOR SMALL HYDRO POWER:



- The main advantage of better partial load behavior does not really apply to large hydropower stations. There are multimachine solutions implemented, where individual machines always work in their design point.
- In case of small hydropower, the costs for the power station are reduced by the reduction in the number of machine sets
 (reduced costs for civil works, electrical and control technology, distribution pipeline, shut-off device)

COST-BENEFIT COMPARISON:

Turbine 1: Francis (existing)

Power output	=	178 kW
Net head	=	27 <i>,</i> 0 m
Discharge	=	800 l/s

Turbine	2:	Francis	(existing
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Power output	=	273 kW
Net head	=	27,0 m
Discharge	=	1200 l/s

Combined operation Turbine 1 & Turbine 2

Power output	=	451 kW
Net head	=	27,0 m
Discharge	=	2.000 l/s



COST-BENEFIT COMPARISON:

HPP XXX (Hn=27,0m) - Two unit operation					
G	erneration 2	2 x (existin	g) Francis per y	/ear	
Discharge [l/s]	Power output [kW]	er output Days Generation [kW] (acc. table) [kW/h] Operation			
2000 (800)	178,0	55	234.950	Two unit	
1800 (600)	135,1	10	32.420	operation	
1600 (400)	82,6	15	29.750	operation	
1400 (200)	21,2	20	10.171	307.292	
1200	273,3	115	754.435	ູ່	
1080	248,9	35	209.052	ol/	
960	221,2	45	238.917	- 19 20	
840	191,3	45	206.649	<u> </u>	
780	173,5	25	104.126	1.513.179	
800	178,0	25	106.796		
720	162,1	15	58.356		
640	144,1	20	69.163	cis /s	
560	126,1	10	30.259	ool ool	
480	105,5	10	25.326	-F 98	
400	82,6	10	19.833		
320	59,3	5	7.120		
240	26,7	5	3.204	320.056	
365 2.140.527 kW/h per year					

- 2 existing Francis units installed in 1950
- Annual production of approx.
 2.140.000 kW/h per year.

COST-BENEFIT COMPARISON (OPTION A):

Turbine 1: Diagonal (new)				
Power output	=	484 kW		
Net head	=	27,0 m		
Discharge	=	2.000 l/s		



COST-BENEFIT COMPARISON (OPTION A):

HPP XXX (Hn=27,0m) - One unit operation						
	Gerneration 1 x Diagonal per year					
Discharge [l/s]Power output [kW]Days (acc. table)Generation [kW/h]Operation						
2000	484,7	55	639.820			
1800	438,6	10	105.270			
1600	389,9	15	140.360			
1400	341,2	20	163.753	s al		
1200	290,8	30	209.396	100		
1000	239,7	55	316.414			
800	188,6	80	362.088			
600	135,9	55	179.359			
400	80,5	30	57.975			
250	19,9	15	7.151			
365 2.181.586 kW/h per year						

- Increase of the annual production of approx. 40.000 kW/h per year
- Cheap solution since only 1 Diagonal unit is required instead of 2 Francis units.

COST-BENEFIT COMPARISON (OPTION B) :

Turbine 1: Francis (existing)Power output =178 kWNet head=27,0 mDischarge=800 l/s

Turbine 2: Diagonal (new)					
Power output	=	290 kW			
Net head	=	27,0 m			
Discharge	=	1.200 l/s			



COST-BENEFIT COMPARISON (OPTION B) :

HPP XXX (Hn=27,0m) - Two unit operation							
Gerneration 1 x (new) Diagonal & 1 x (existing) Francis per year							
Discharge	Power output	Power output	Difference in	Days	Difference i.	Generation	Operation
[l/s]	(new) [kW]	(old) [kW]	Power output [kW]	(acc. table)	Gen. [kW/h]	[kW/h]	Operation
2000 (800)		178,0		55		234.950	
1800 (600)		135,1	0.0	10	0	32.420	Two unit
1600 (400)		82,6	0,0	15	0	29.750	operation
1400 (200)		21,2		20		10.171	
1200	290,8	273,3	17,5	115	48.375	802.683	
1080	263,2	248,9	14,3	35	11.991	221.067	
960	233,9	221,2	12,7	45	13.752	252.648	
840	204,7	191,3	13,4	45	14.463	221.067	
800	193,9	178,0	15,9	25	9.531	116.331	_
780	189,0	173,5	15,5	25	9.323	113.423	na I/s
720	174,5	162,1	12,4	15	4.463	62.819	00
640	153,4	144,1	9,3	20	4.475	73.638	l Dia
560	132,0	126,1	5,9	10	1.419	31.683	
480	111,2	105,5	5,7	10	1.379	26.699	
400	91,1	82,6	8 <mark>,</mark> 5	10	2.044	21.868	
320	71,2	59,3	11,9	5	1.428	8.544	
240	48,3	26,7	21,6	5	2.594	5.797	
365 125.235 2.265.557 kW/h per year							

- Increase of the annual production of approx. 125.000 kW/h per year
- Efficiency in partial load of the Diagonal turbine is better than the small existing Francis
- Operation of small existing Francis only required if discharge is above 1.200 l/s

REFERENCES

OVERVIEW DIAGRAM OF GEPPERT DIAGONAL TURBINES IN OPERATION:



ENNS/FLACHAU DH-53 (Austria 2018)

Power output: Net head: Discharge:

616 kW 56,8 m 1.200 l/s



STILLUP DH-127

(Austria 2018)

Power output: Net head: Discharge: 1.623 kW 26,2 m 7.000 l/s



RIEGERBACH DH-88

(Austria 2021)

Power output: 2 Net head: 2 Discharge: 2

896 kW 30,4 m 3.300 l/s



JELOVICA 2 DH-62 (Montenegro 2017)

Power output: Net head: Discharge:

636 kW 48,0 m 1.500 l/s



GEPPER HYDROPOWER THANK YOU!

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