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Evaluation of Hydro-kinetic Technologies and Application in Water Engineering

Session GM2.6 - Assessing and monitoring geomorphic processes across scales

room G1, Thursday, 18 April 2024, 17:35 EGU23-14619

Agenda

- Introduction
- Challenges
- Review of Hydro-kinetic technologies
- Analysis and Selection

Introduction

Scotland
Plenty of low head
Water Streams
21 TWH Consumption

Significance

- 1.5% of electricity for pumping, sewage treatment, water meters
- energy self-sufficiency

Objectives

- Evaluation of small hydro-kinetic systems
- Assess various practical aspects such as installation and constraints
- Perform a techno-economical comparison

Challenges

Geographical Isolation

High Infrastructure Costs

Energy Loss in Transmission

Unreliable Grid Connectivity

Energy Access Inequity

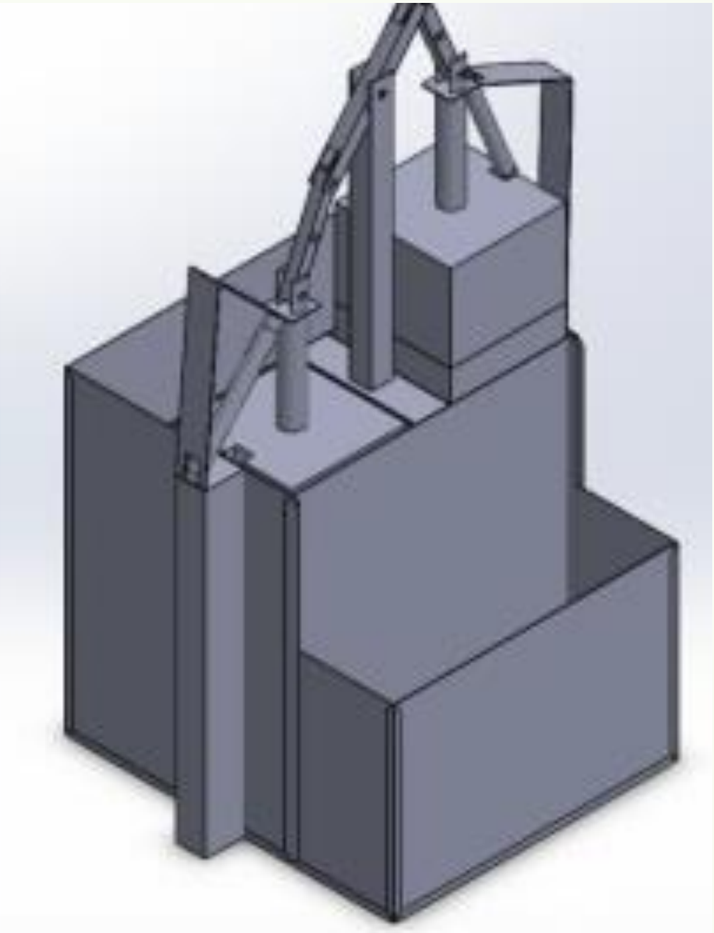
Review of small hydro-kinetic systems

7 technologies are assessed herein

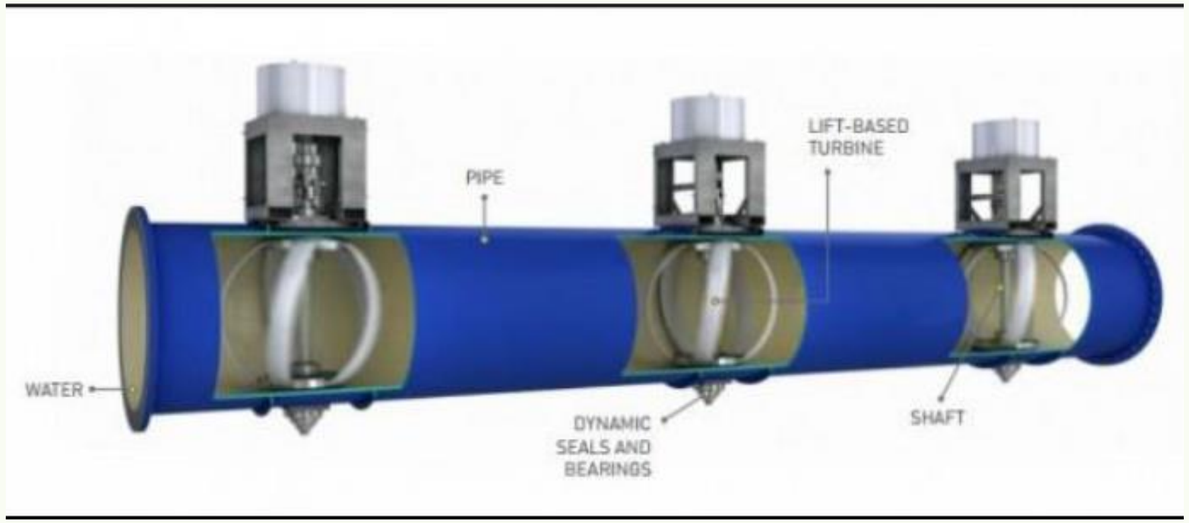
1.Water Engine Technology

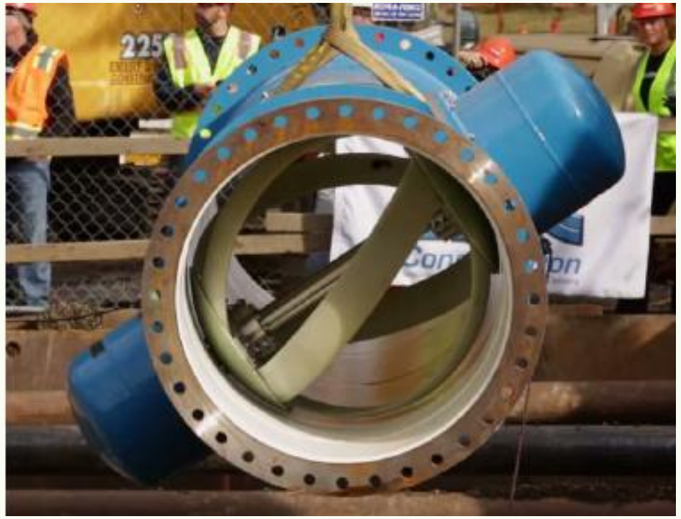
15 KW generated from 1000 l/sec flow

Useful to very low water head and high discharge



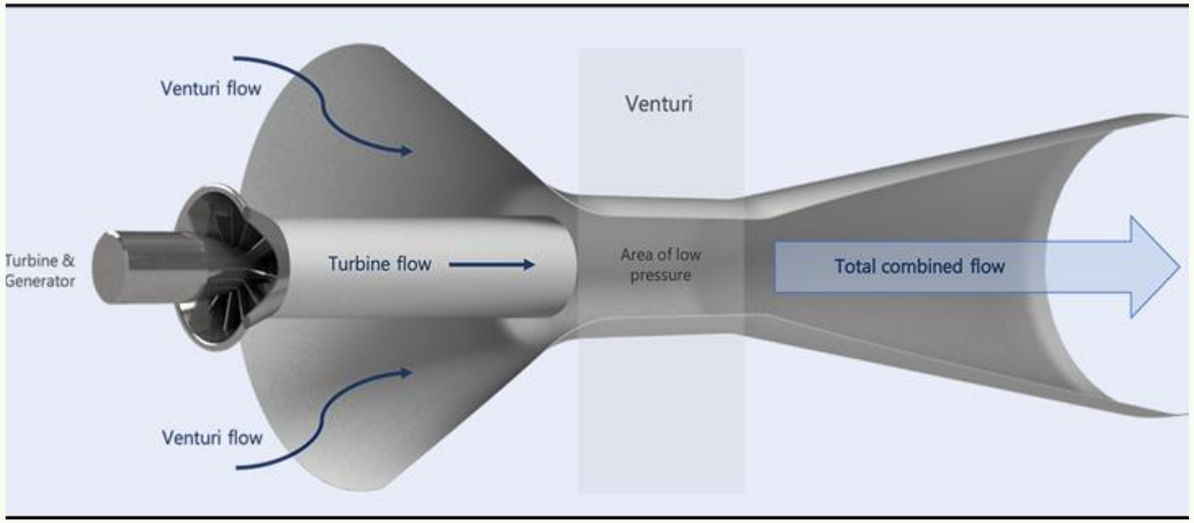
2.Lucid Pipe

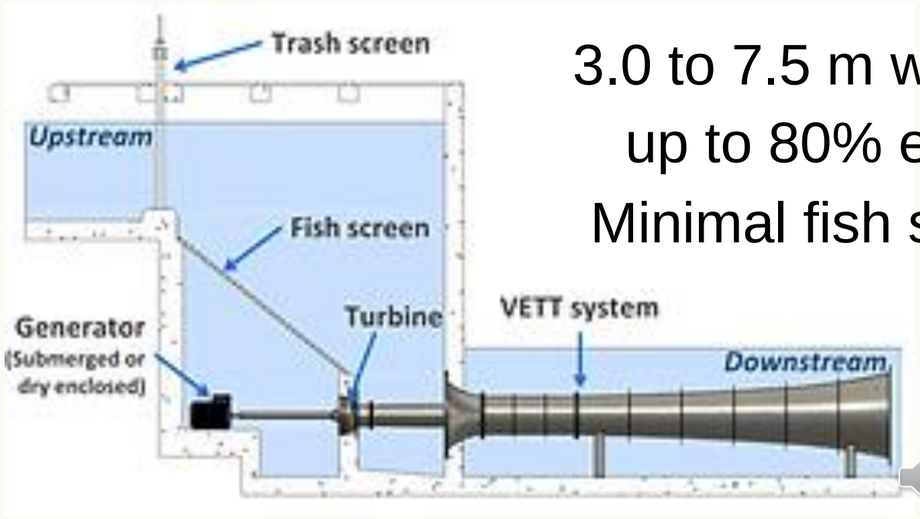




velocity of 0.9-2.8m/s to generate between 20-100 KW
60-70% efficiency

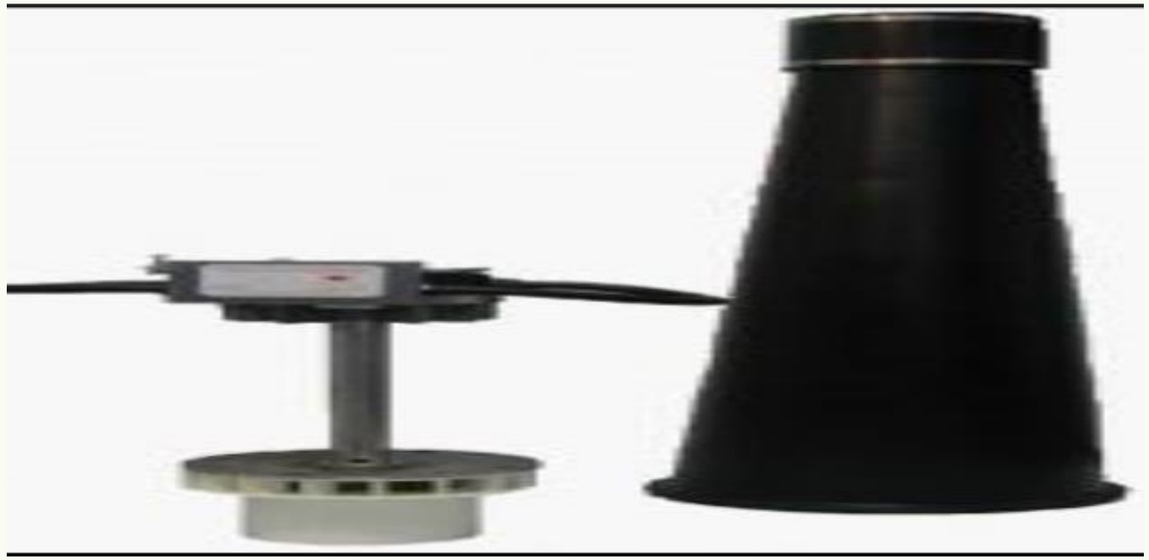
3.Venturi-Enhanced Turbine Technology (VETT)





3.0 to 7.5 m water head
up to 80% efficiency
Minimal fish screening

4.LH1000 LOW HEAD STREAM ENGINE

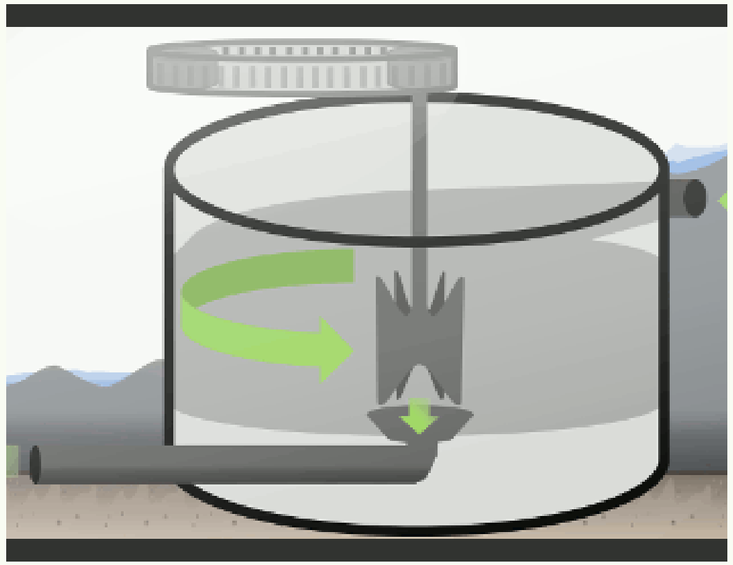


very low head (0.6-3 m)

1.5 KW from 30-60 l/sec flow rate

easy to construct and set up with small diameter

5.Kouris Centri Turbine Generator

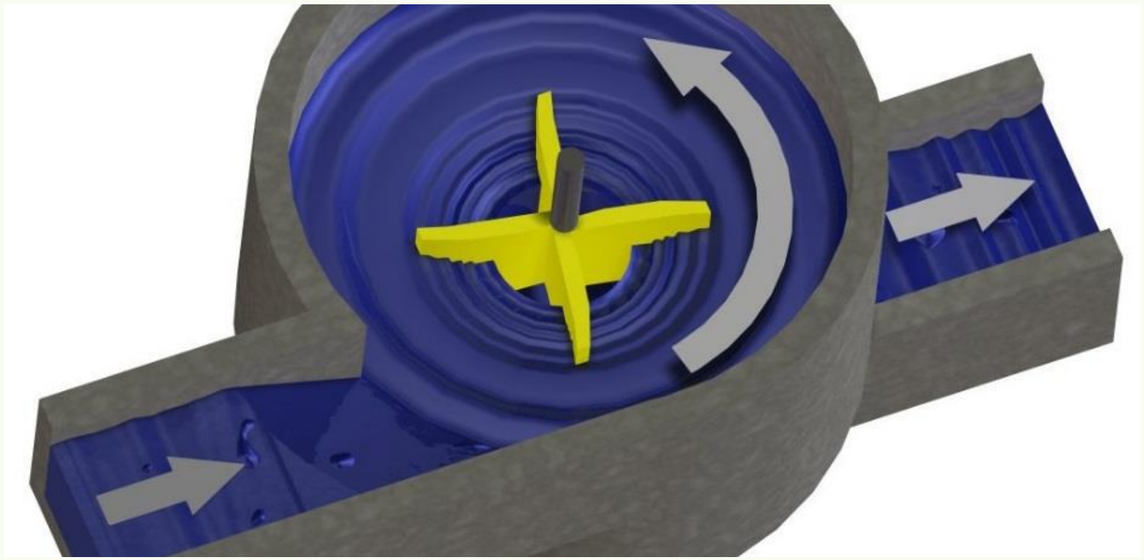


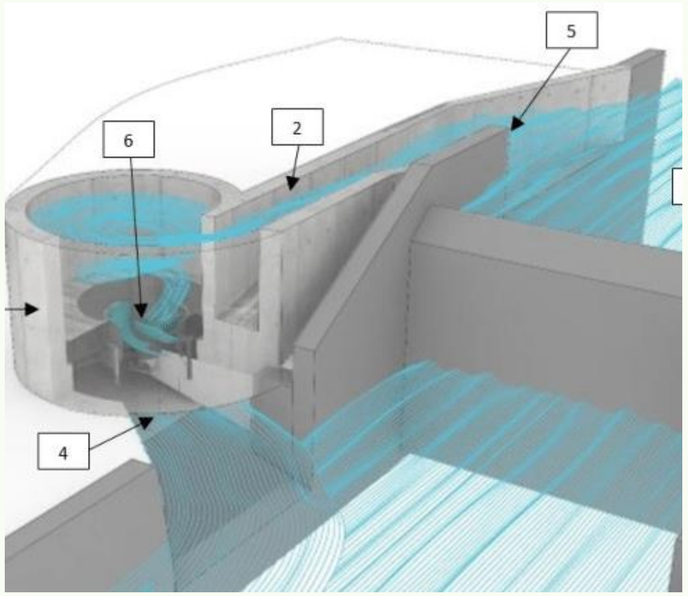
10 KW generation for 1000 l/ sec flow

Easy construction and setup

can be retrofitted into the existing system

6.Gravitational Vortex Converter



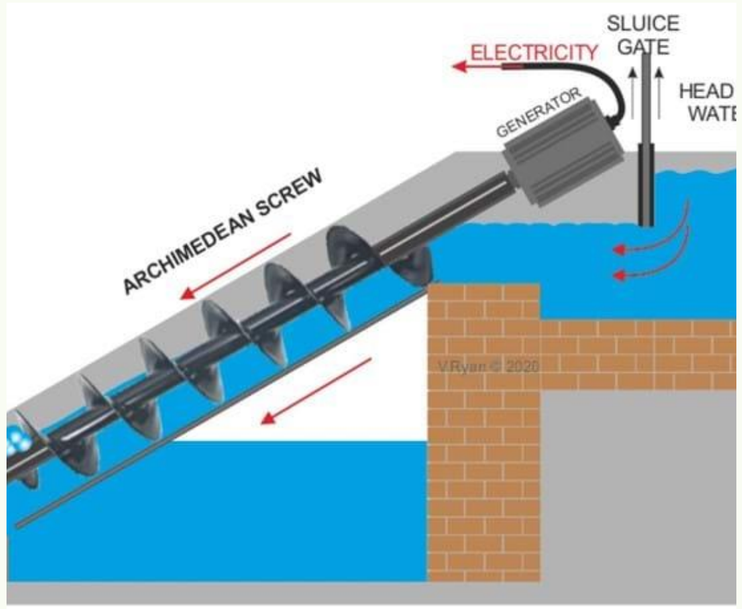


-10 KW energy from 0.9 m3/sec water flow

-Efficiency of around 80%

-Suitable for canal systems, and outlets.

7.Screw Turbine



-Up to 500 KW from from 100-1500 l/sec flow

-High efficiency compared to low-head turbines

-Relatively large size leads to difficult maintenance

Analysis

1.Ranking of the Technologies on Various Criteria

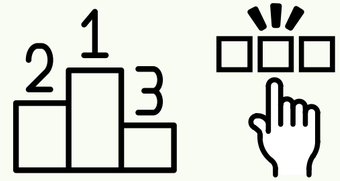
	Technologies	Lucide Pipe	Venturi Enhanced	LH1000	Koursi-Centri	Gravitational Vortex	Screw	Water Engine
Ranking Criterion								
1. Health and Safety								
	System Safety	2	2	2	2	2	2	2
	Human Life Risk	2	2	2	2	2	2	2
	Equipement Protection	2	2	2	2	2	2	2
2. Technical Criterion								
a. Design	Design Discharge	0	2	1	2	2	2	2
	Pressure Head	0	2	1	2	2	2	2
	System Efficiency	1	1	1	1	1	1	1

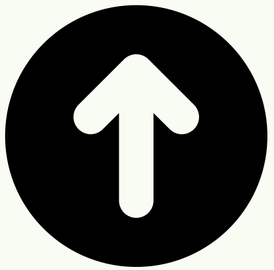
b. Compatibility	Physical Constrains	2	2	2	2	2	1	2
	Control System	2	2	0	1	2	1	1
	Compatibility with existing system	0	1	0	1	1	2	0
3. Health and Environmental Constraints								
	Degradation of Water Quality	2	1	2	2	2	1	2
	Oil Discharge	1	1	2	1	2	1	2
	Region of Water Stagnation	2	2	1	2	2	1	2
4. Employability								
	Modularity of the System	1	2	2	2	1	2	2
	Maintenance and Repair	1	1	0	2	2	1	1
	Success in Installation and Operation	2	0	2	2	2	2	1
Total Score		**20**	**23**	**20**	**26**	**26**	**23**	**24**

2. Financial Analysis

Technologies	Lucide Pipe	Venturi Enhanced	Koursi-Centri	LH1000	Gravitational Vortex	Screw	Water Engine
Capacity (KW)	14	4	3	2.65	5	6	5
1.Capital Expenditures (CAPEX ,000£)	133.9	56.7	19.4	27.4	69.5	243	79.2
2.Operational Expenditures (OPEX ,000£)	64.2	79.8	45.5	29.3	58.8	57	45
Total Expenditures (,000£)	198.1	136.5	64.9	56.6	128.3	300	124.2
Net Present Value (NPV ,000£)	-60	-32.2	3.8	-18.7	-24.8	-176	-45.95
Internal Rate of Return (IRR, %)	-4.9	-2.3	4.8	-4.0	1.6	-20	-14.2
Equipment Life (Year)	20	40	40	30	40	25	25
Simple Payback Period (Year)	No Payback	No Payback	Initial Payback at year 18	No Payback	Payback at Year 35	No Payback	No Payback
Initial Setup Cost (£/KW)	**6,750**	**9,500**	**4,334**	**8,020**	**8,400**	**26,167**	**10,000**

Selection



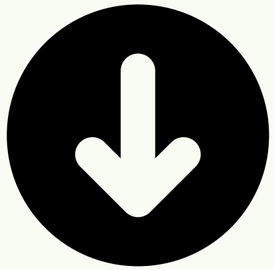


Kouris-Centri turbine and Gravitational Vortex achieved 26/30.
Low IRR
Vortex more profitable

Water Engine achieved 24 out of 30. System fails to generate profit.

Venturi enhanced turbine and Screw generator achieved 23/30.
Both systems fail to generate profit with relatively high setup cost.

Lucid Pipe achieved 22. System did nit match the criteria of treatment plant. Score will be higher in different sites.



LH100 turbine achieved the least score of 20 out of 30. Unit is relatively small. Multiple units need to be placed to achieve higher score.

Any Question?

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