OLLSCOIL TEICNEOLAÍOCHTA BHAILE ÁTHA CLIATH
TU DUBLIN
TECHNOLOGICAL UNIVERSITY DUBLIN

Residential Micro Hydro Design for Sustainable Generation

Student : Fionn Moore Fogarty
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Introduction

Climate change – need for renewable energy
Disadvantaged populations lack access to stable power supplies / any power
This project could provide sustainable scalable solutions

Objective

Investigate and analyse a potential small Pico/hydro power solutions by harnessing the power of a local stream to supplement power supply for residential use.

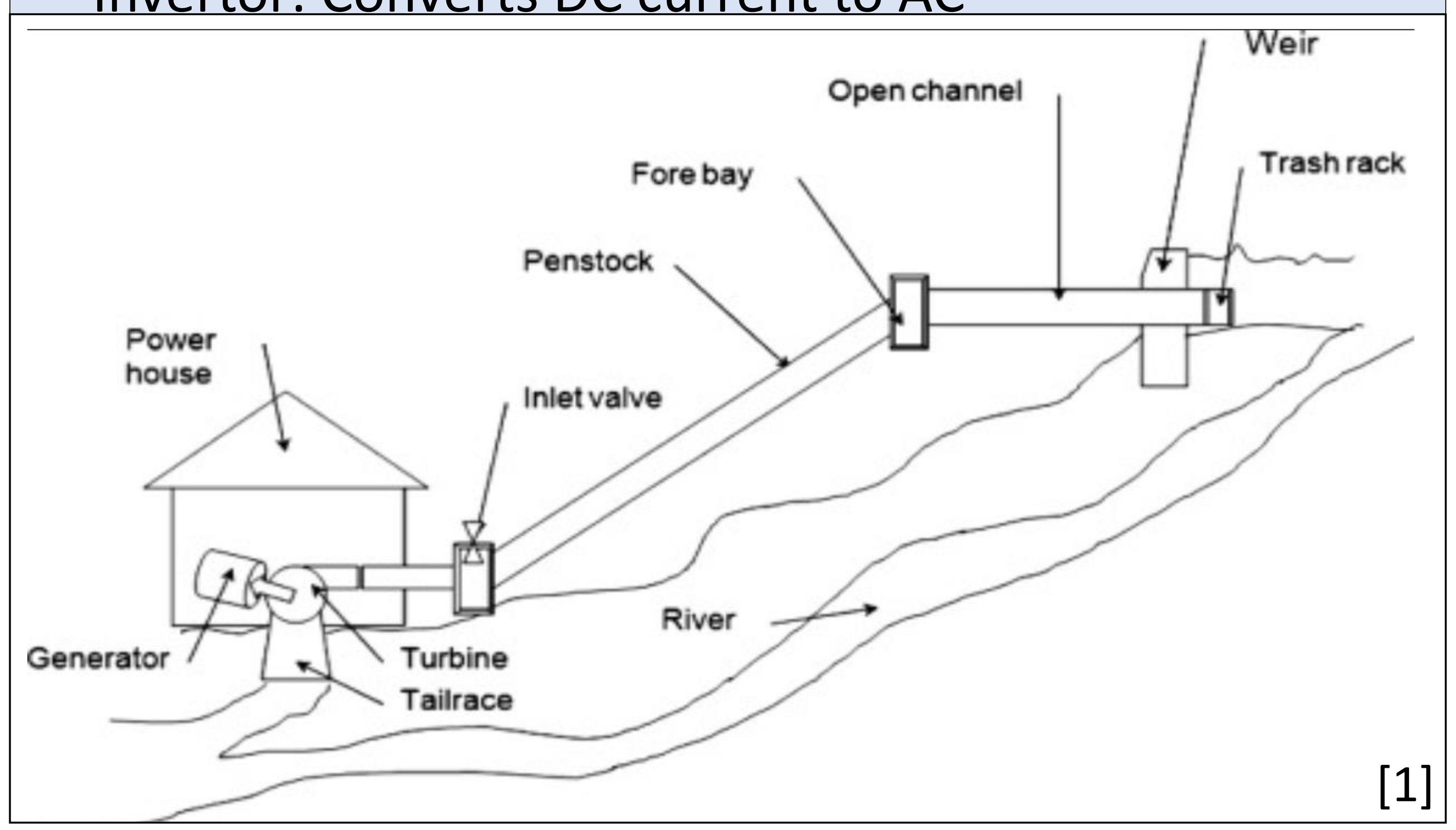
Aims

Recommend solutions to reduce reliance of non-renewable energy from National Grid.
Preform cost analysis on recommendations to determine feasibility

Components of a Hydro-Power system

Hydro-power systems typically consist of numerous components and systems that convert the flow of water first to rotational movement and then to electricity.

- The head is the difference in height between the turbine and the forebay. The flow is the volume of water (m^3/s)
- Penstock: Pipe that carries water to the turbine.
- Turbine: Converts waterflow to rotational movement.
- Generator: Converts rotational movement to electricity.
- Rectifier: Converts AC current to DC
- Invertor: Converts DC current to AC



[1]

Stradbally Field Research

A visit to Stradbally in Nov gave insights around the Challenges and benefits on setting up a hydro system.

Key Insights

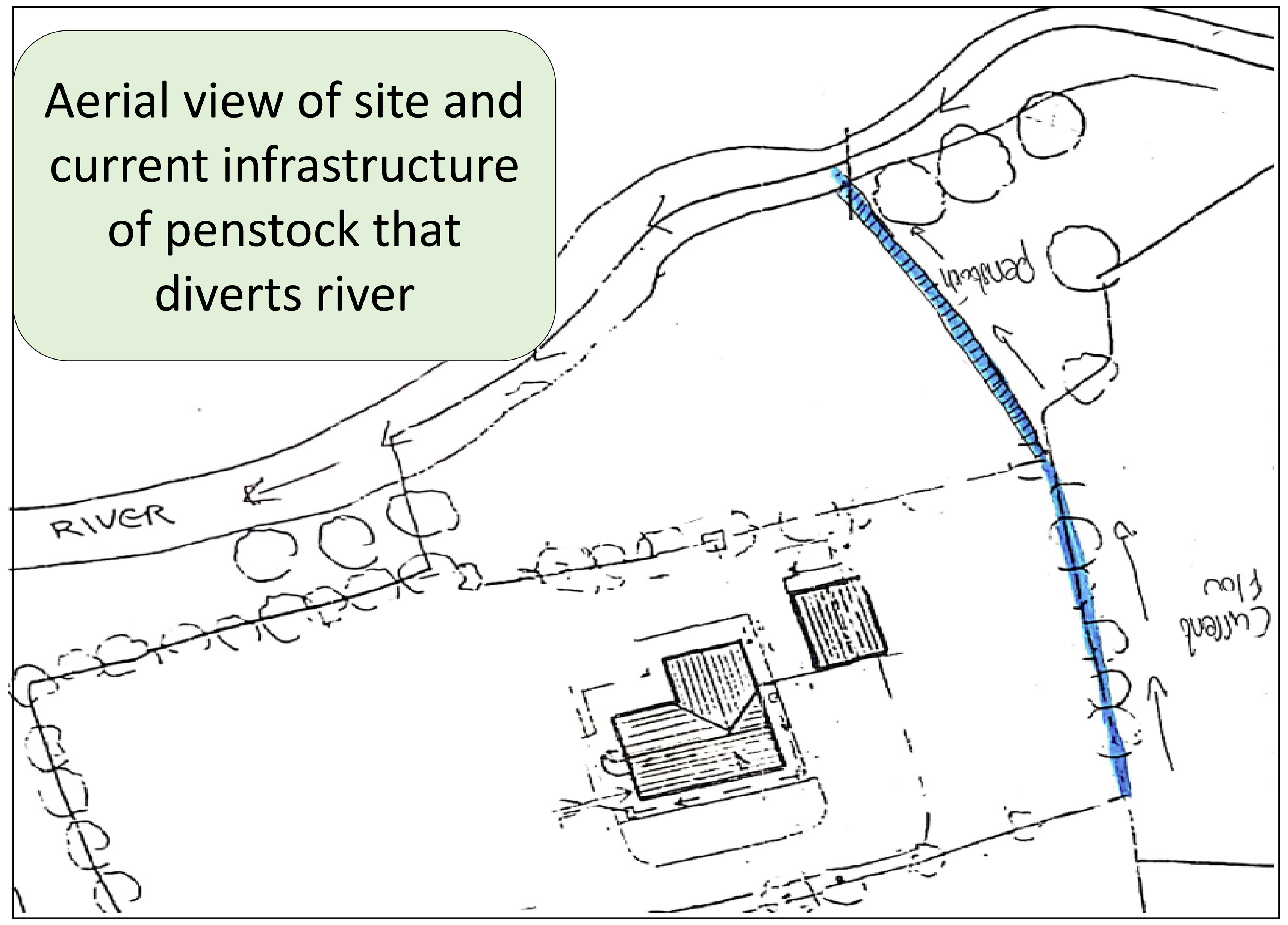
Stradbally produces of 11kW
Water Flow is dependent on weather conditions
Inefficient tailrace can effect total head
Dump load needed to protect machinery during surge
Powers residential home and farm

Period	Electricty Usage (kWh)	Total cost (€)
20 Jan 2021 to 19 Feb 2021	676	112.47
20 Feb 2021 to 19 Mar 2021	615	108.18
20 Mar 2021 to 19 Apr 2021	584	145.72
20 Apr 2021 to 19 May 2021	2468	431.98
20 May 2021 to 19 Jun 2021	742	169.91
20 Jun 2021 to 19 Jul 2021	684	158.13
20 Jul - 16 aug 2021	1634	333.16
17 Aug - 19 Sept 2021	1092	250.93
20 Sep 2021 to 12 Oct 2021	680	165.62
13 Oct 2021 to 19 Nov 2021	1454	336.83
20 Nov 2021 to 19 Dec 2021	1333	314.59
20 Dec 2021 to 19 Jan 2022	1387	346.89
TOTAL	13349kWh	€2,541.25

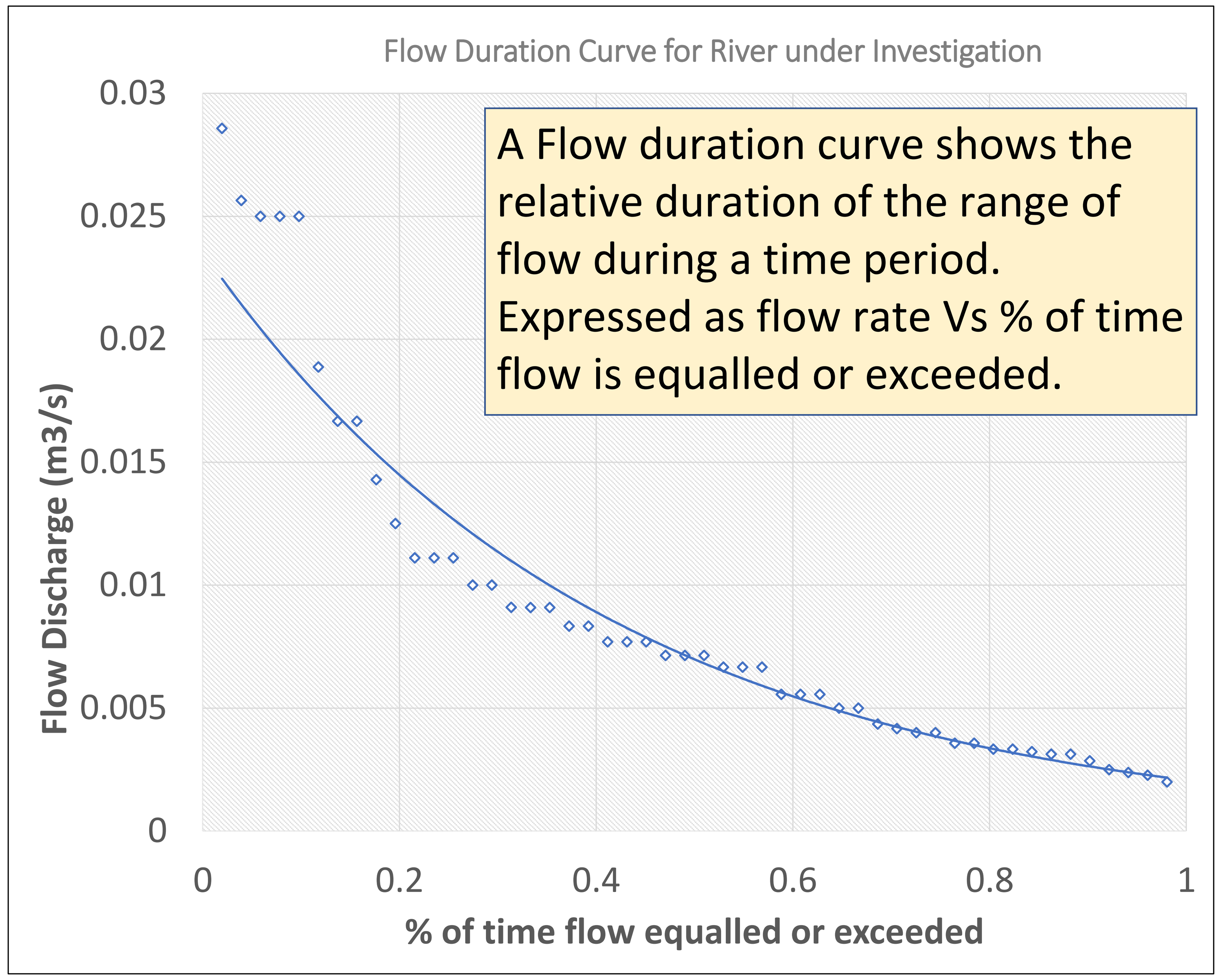
EU Targets: 1990 Gas Emissions reduced by 40% -2030
Carbon neutral – 2050
[2]

Reliance on fossil fuel needs to be reduced
Fuel escalation rates increasing

Average Irish household 4200kWh P.A
Dwelling requires 13,349kWh, Sustainable alternative required . [3]



Aerial view of site and current infrastructure of penstock that diverts river

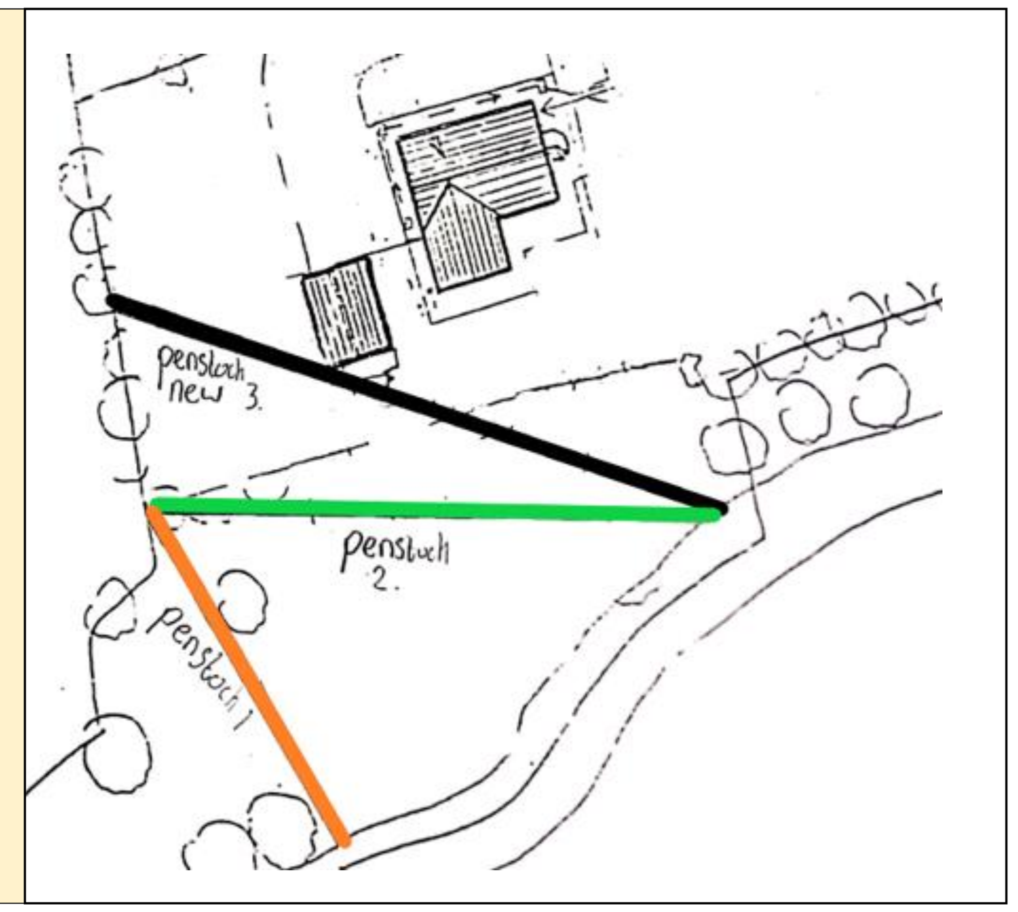


Results from Flow Duration Curve

Biweekly flow measurements recorded between October 2021 & March 2021
Design Flow is the expected flow at the 50 percentile rate which is considered appropriate for a domestic set
Analysis showed a 50% Design Flow at $0.007 m^3/s$

Penstock Analysis

- To increase head, alternative penstock infrastructures analysed
- Darcy Weisbach equations used to determine optimal penstock location
- HDPE penstock



Proposed Penstock	Length (m)	Head (m)	Head Loss (m)	Head Loss Due to Friction (m)
Penstock 1	36	4.6	0.014	4.586
Penstock 2	67	6.45	0.0261	6.4239
Penstock 3	82	7.2	0.032	7.168

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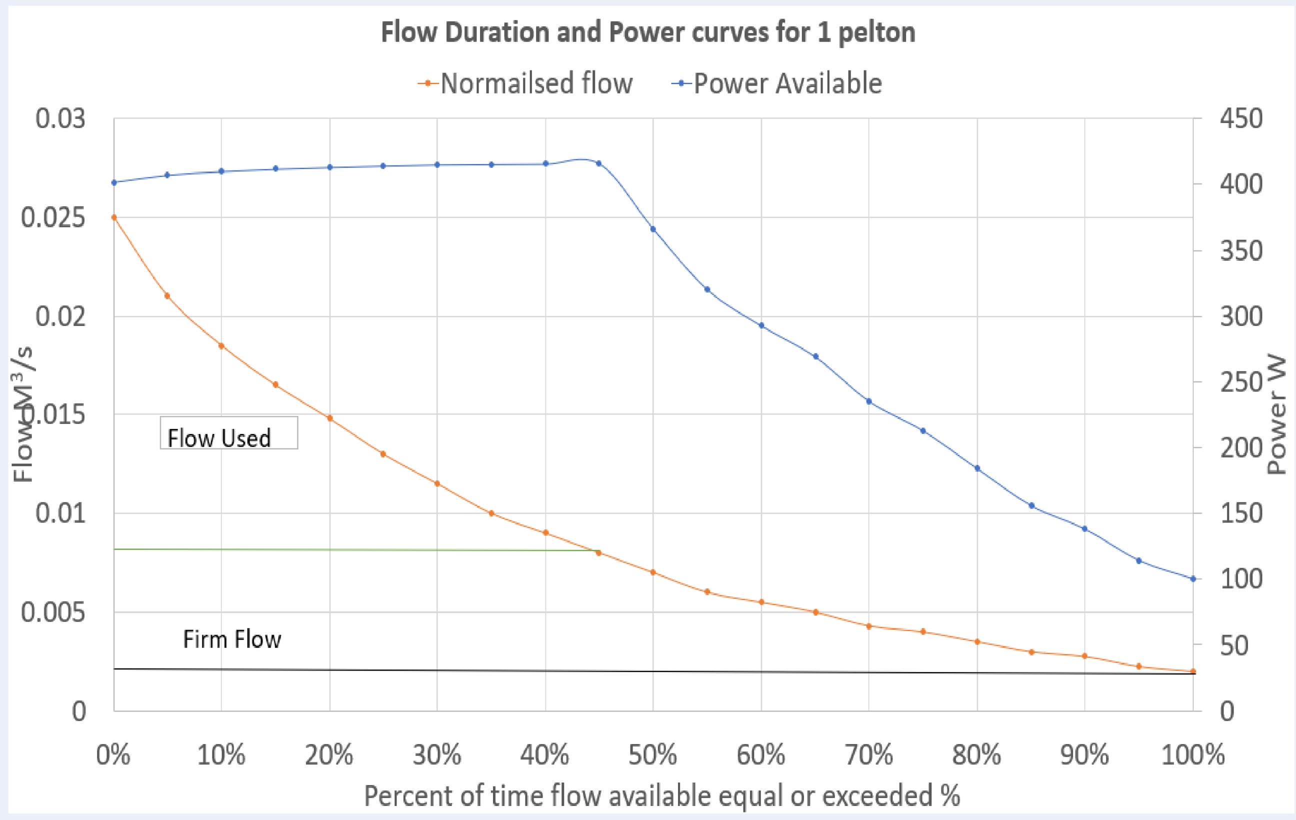
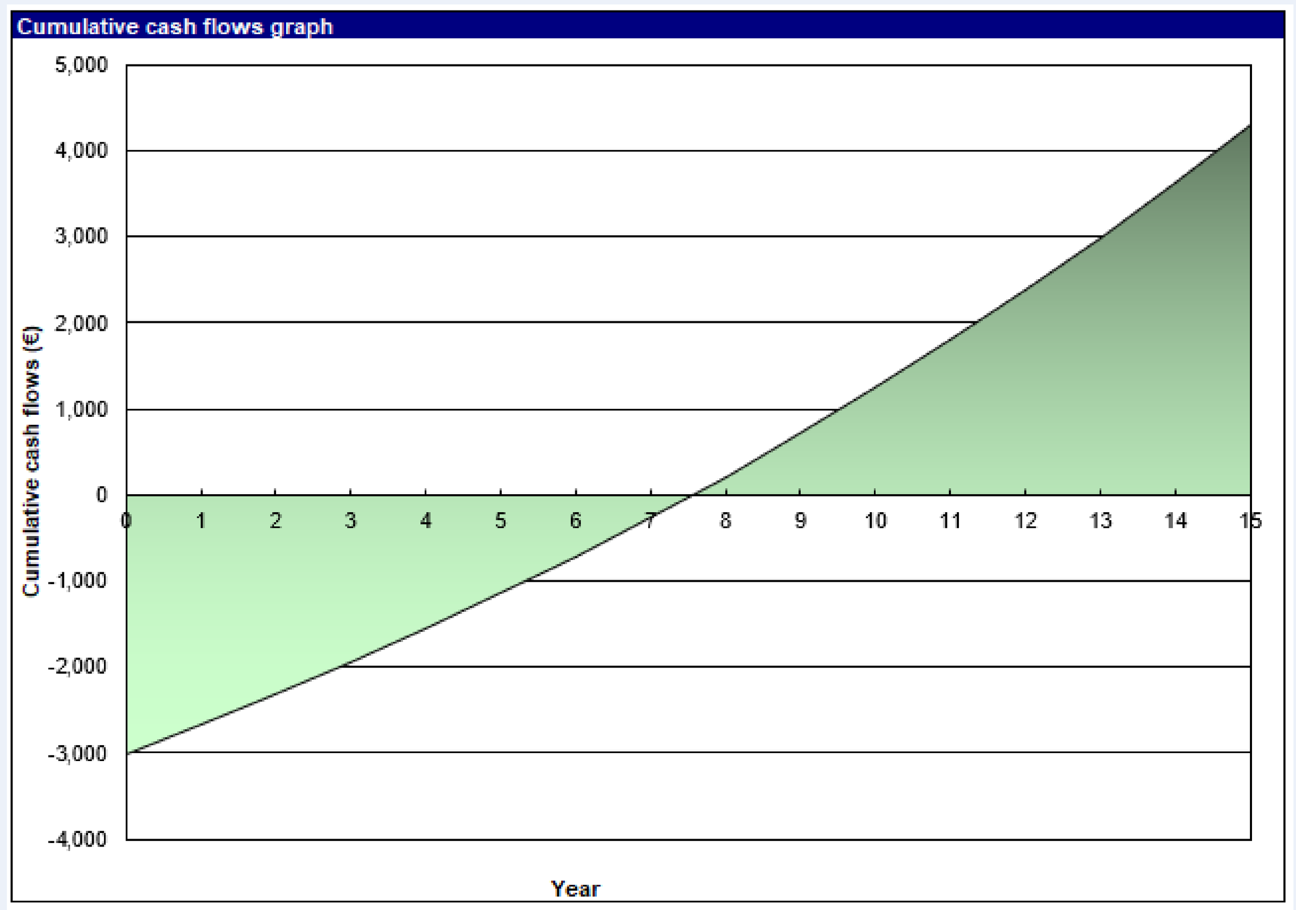
Single Turbine System

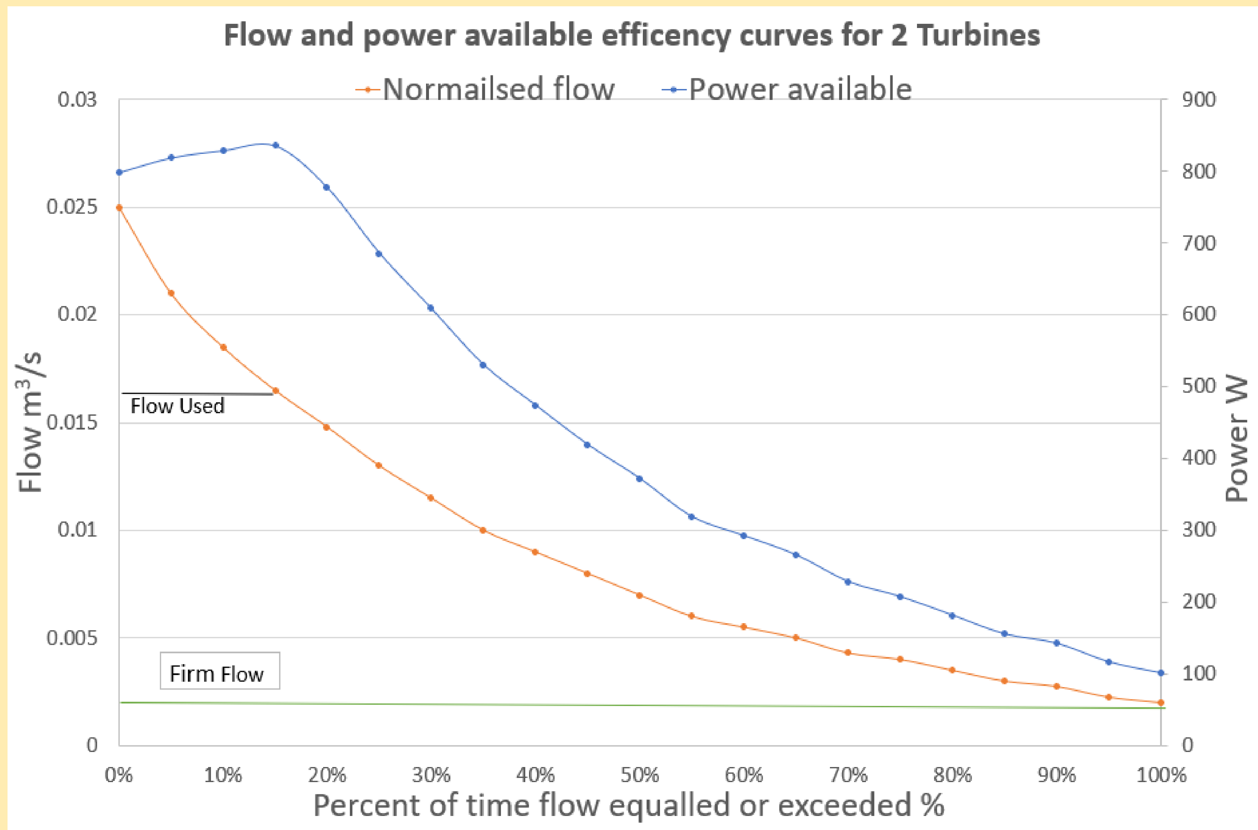
One Pelton turbine to harness < 0.008m^3/s
400W peak power available 45% of time
Total initial setup costs= 3007 Euro
Expected ROI is 7.5 years
Cheap & Straight forward, and efficient
Excess water wasted over 0.008m3/s

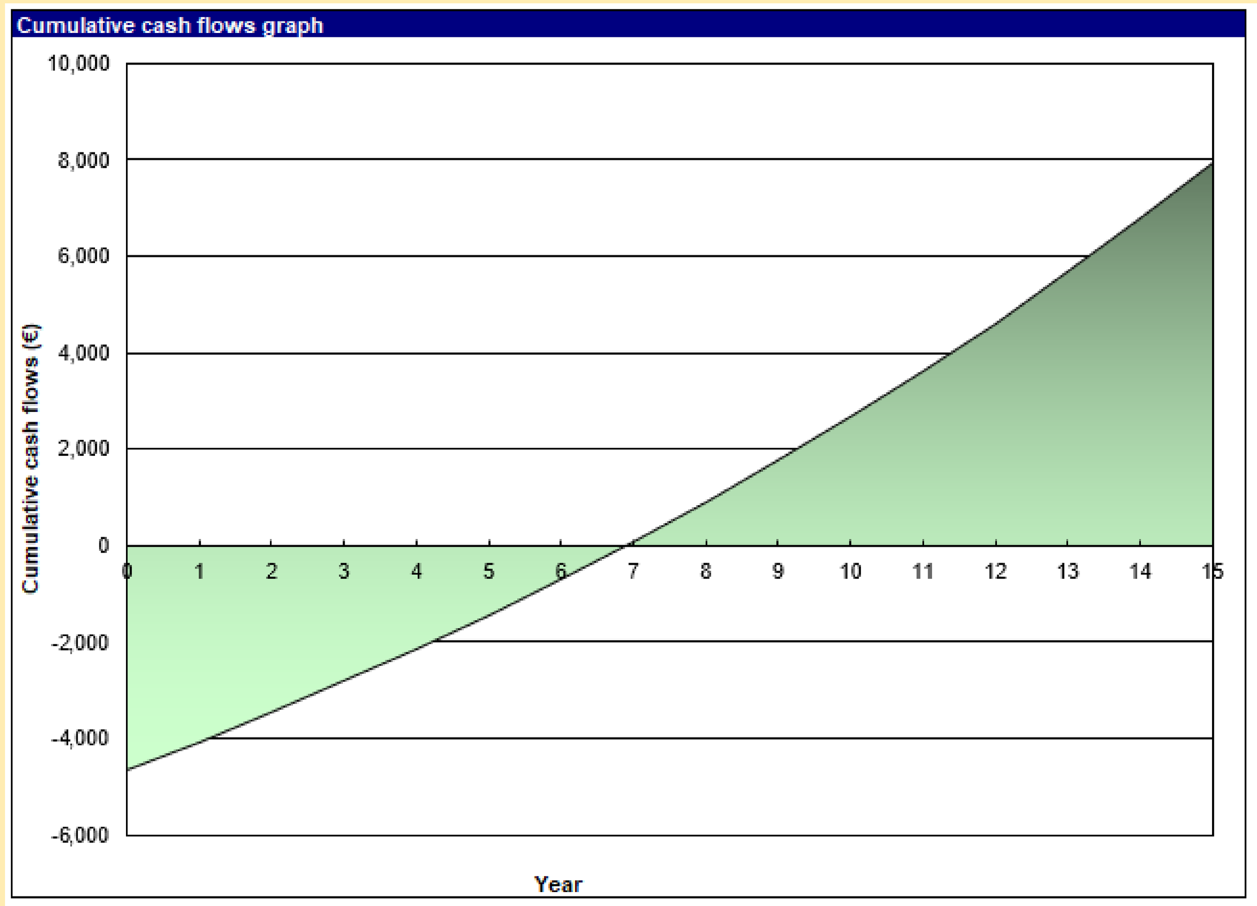




Double Turbine System

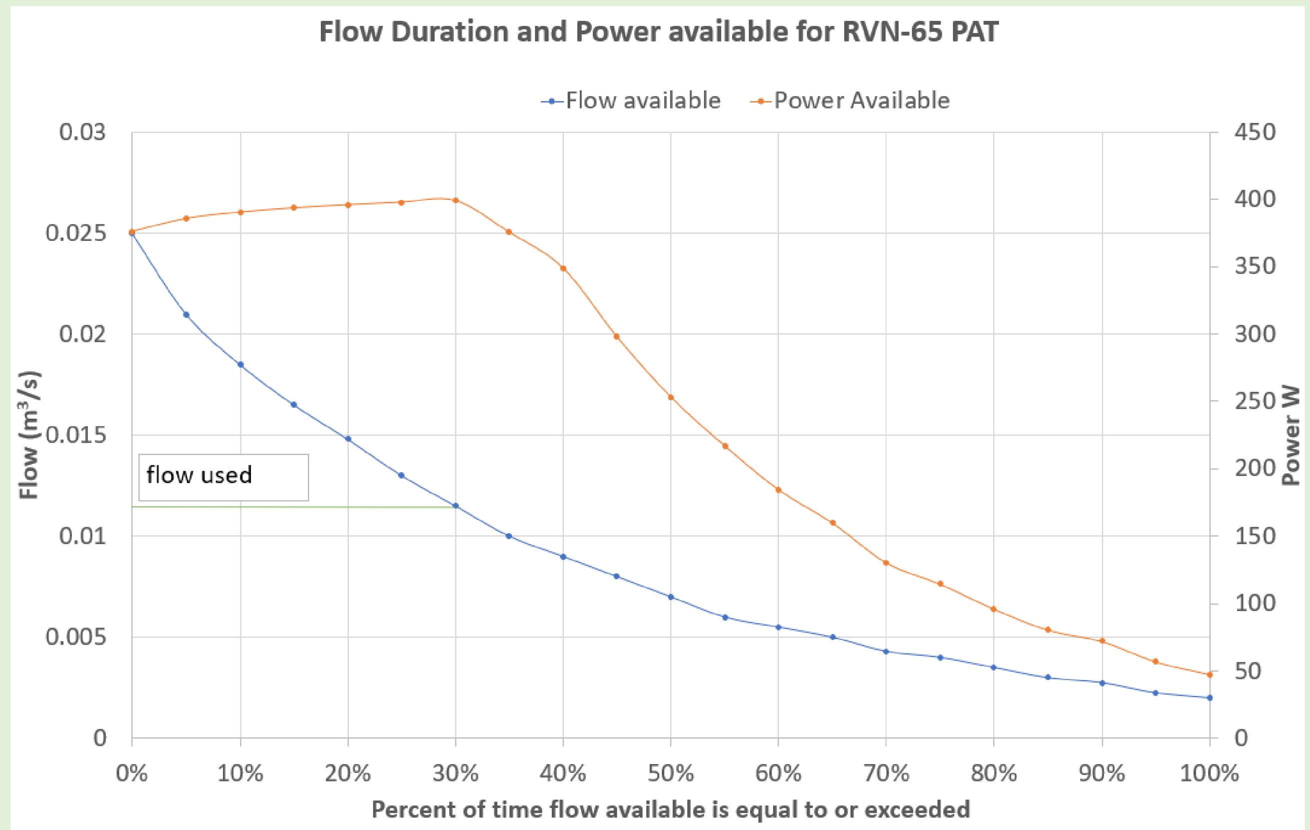
Two Pelton turbine to harness < 0.016m^3/s
800W peak power available 15% of time
Total initial setup costs= 4646.48 Euro
Expected ROI is 5.5 years
Straight forward, and Efficient,
Low water wastage > 0.016m3/s
High initial costs

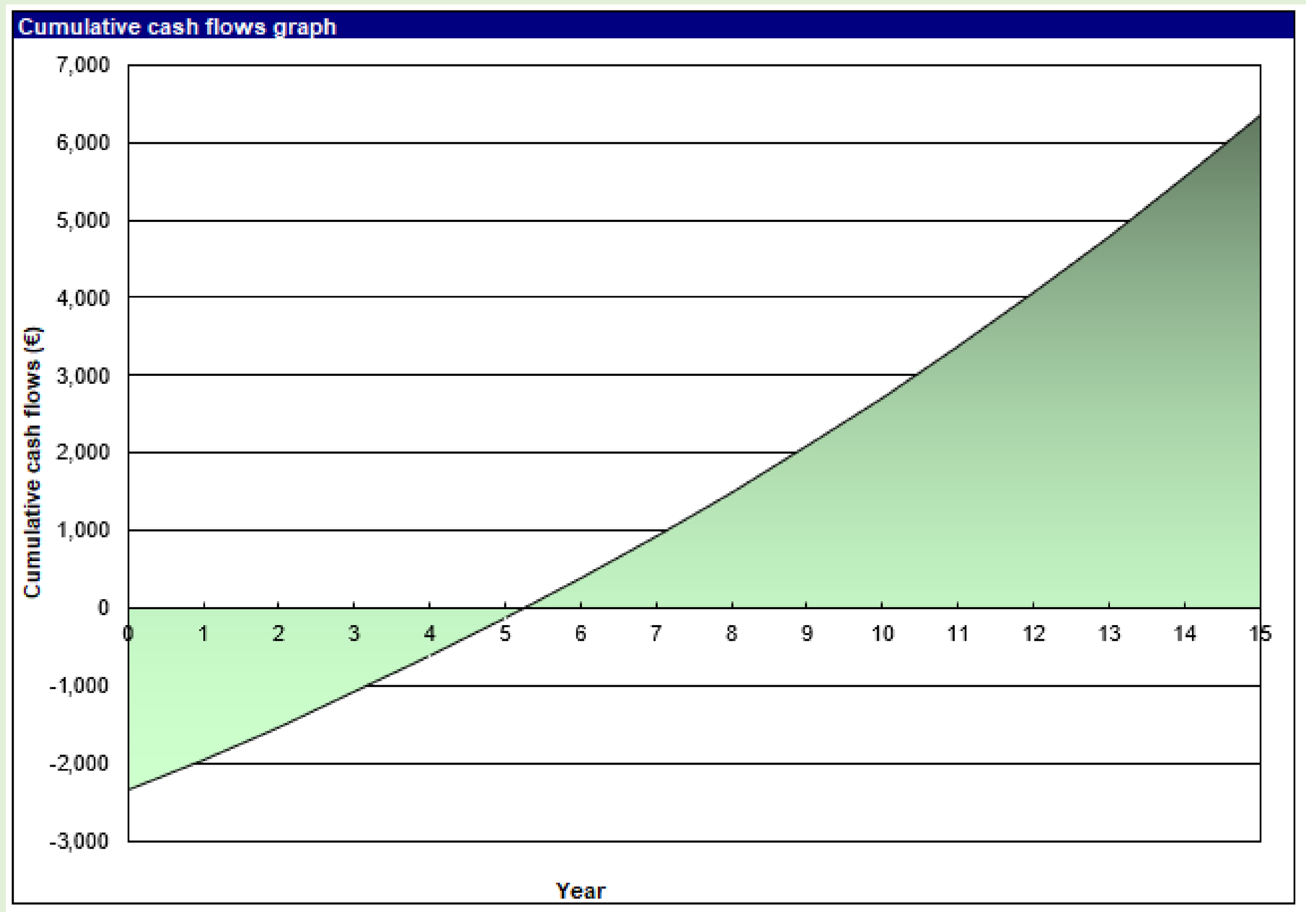




Pump as Turbine (PAT)

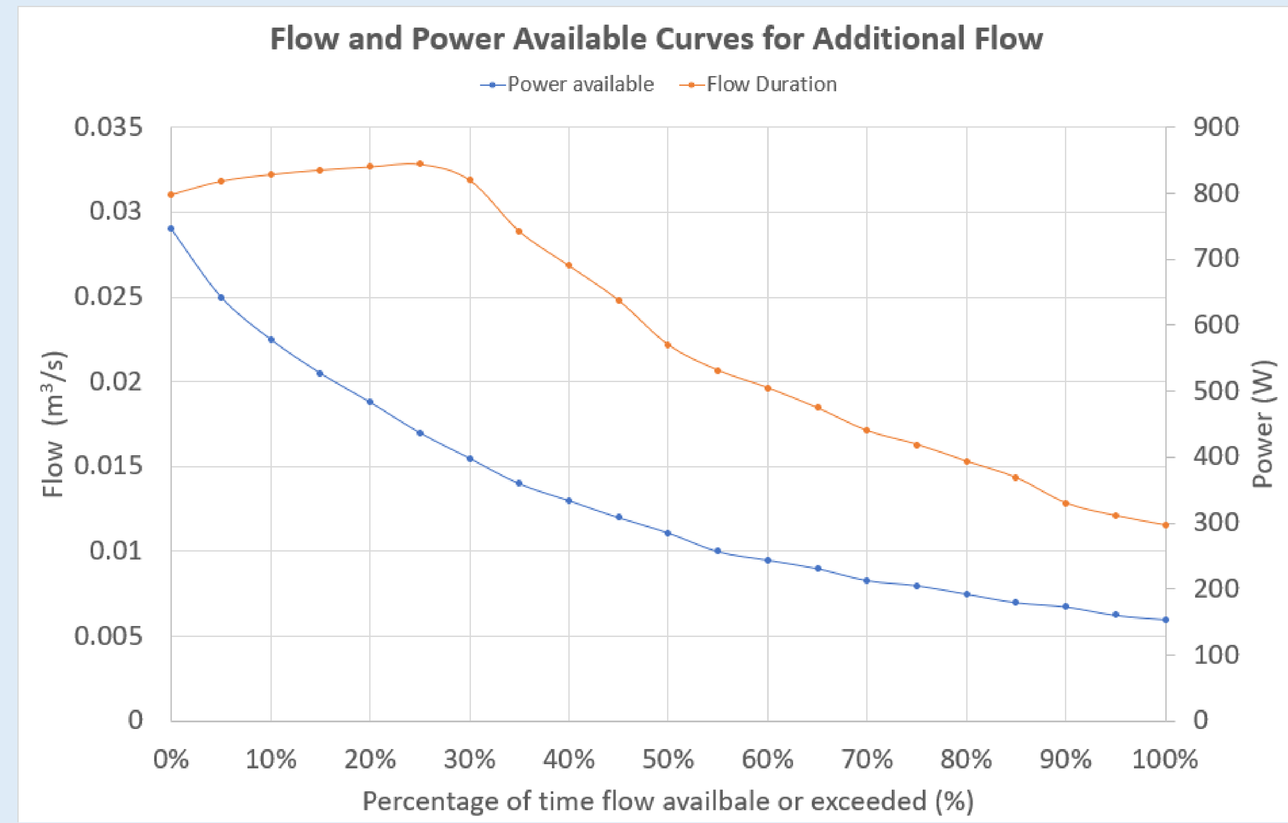
PAT to harness < 0.011m^3/s
400W peak power available 30% of time
Total initial setup costs= 2353 Euro
Expected ROI is 5 years
Low water wastage > 0.011m^3/s & low cost (cheapest option)
Lower efficiency

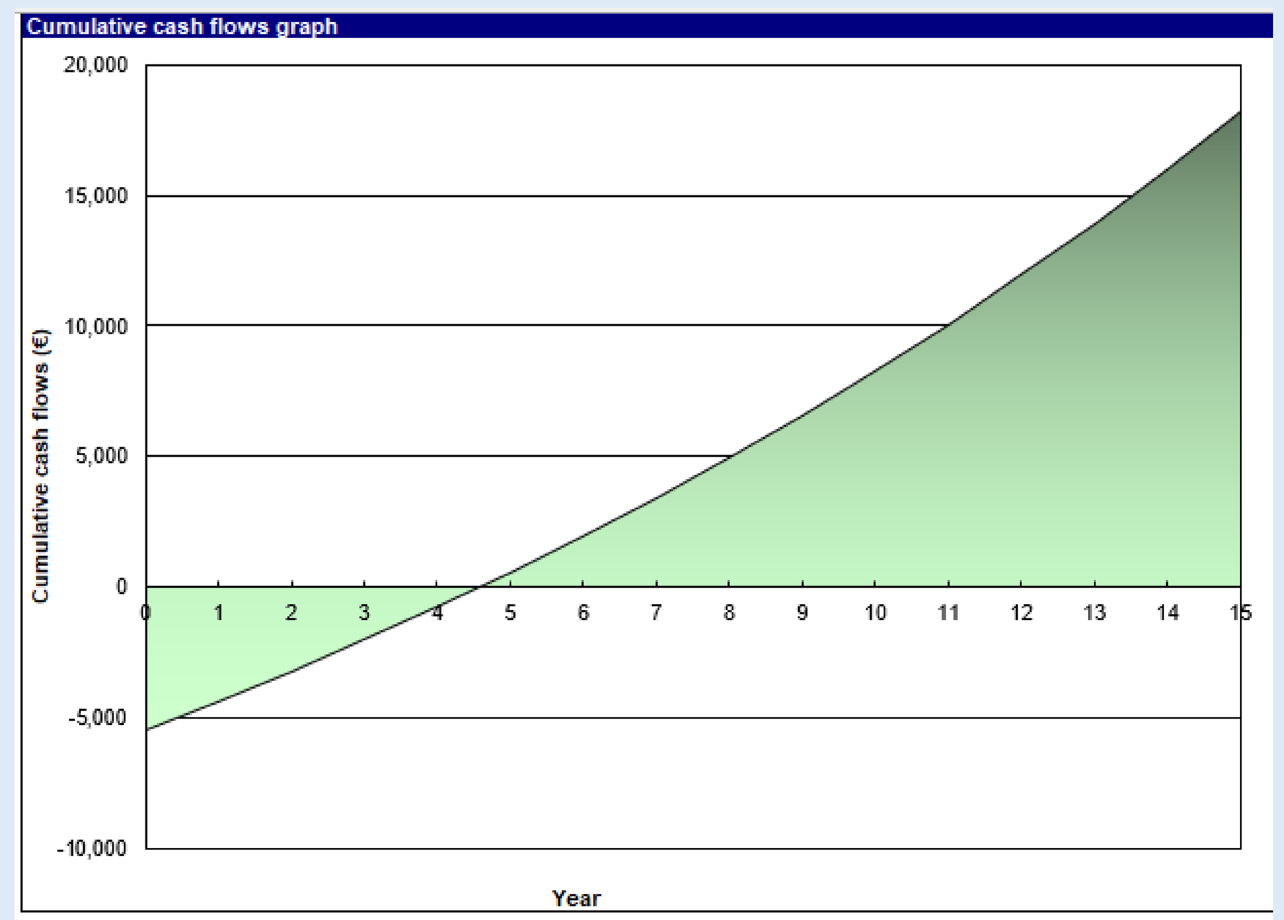




Double Turbine + Solar Panel

Two Pelton turbine to harness < 0.016m^3/s
800W peak power available 30% of time
Total costs= 5468.16 Euro
Expected ROI is 4.5 years
Efficient, low water wastage > 0.016m3/s
High initial costs & Complex Setup





Conclusion

The system with two Pelton turbines working in conjunction with each other is the more robust solution. Whilst the double turbine with solar panel gives a greater ROI it would make more sense to implement the solar as a direct supplement to the house rather than use it to pump the water to a reservoir.

The scale of this project was small, however the learnings are scalable to support larger scale projects and could be used as a blueprint for rural communities with no current access to electricity.

Rising energy costs and climate consciousness made this project relevant to todays global challenges.

References

[1} T. J. E.S.N.Raju P, Distributed Energy Resources in microgrids, Greater Noida: ACADEMIC PRESS , 2019

[2] European Union, "European Commission," September 2020. [Online]. Available: https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2030-climate-energy-framework_en. [Accessed 16 10 2021].

[3] SSE Airtricity, Bill summary, Dublin: SSE Airtricity, 2021.