Interreg Atlantic Area
HY4RES

Co-funded by the European Union

BLUE AND GREEN ENVIRONMENT

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Balancing nature restoration and hydropower production: Analysis of a fish-friendly centrifugal screw pump-as-turbine

Naufal Riyandi, John Gallagher, Aonghus McNabola

12/03/2025

PRESENTER : NAUFAL RIYANDI
ORGANISATION: TRINITY COLLEGE DUBLIN
EMAIL : RIYANDIN@TCD.IE

www.hyr4res.eu

Interreg Atlantic Area HY4RES | Co-funded by the European Union

Background

The European Union (EU) implemented the Nature Restoration Law (NRL) on 18 August 2024

Restore aquatic ecosystems

Protect biodiversity, such as fish species

Enhance waterway connectivity by removing barriers along 25,000 km of rivers by 2030.

NRL Article 4 and Article 7

Challenge of the NRL

Impacts on Run-of-River micro hydropower development:

- Existing barriers can be an important component.
- Turbines can negatively affect fish populations.

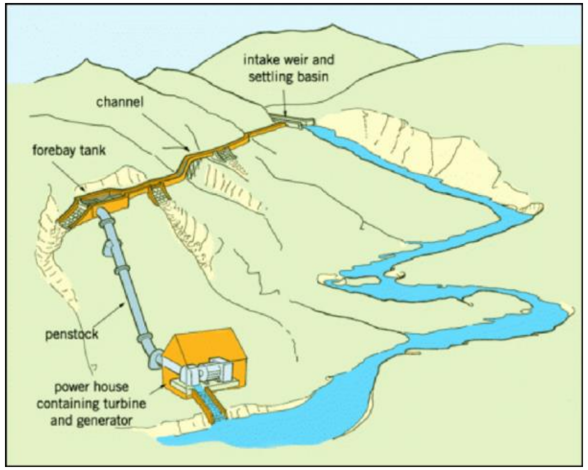


Figure 1. Micro Hydropower Run-of River (Ottow 2015)

Figure 2. Hydro Turbine (This Photo by Unknown Author is licensed under CC BY-SA)

Alternative: Fish-friendly Technology

Solution

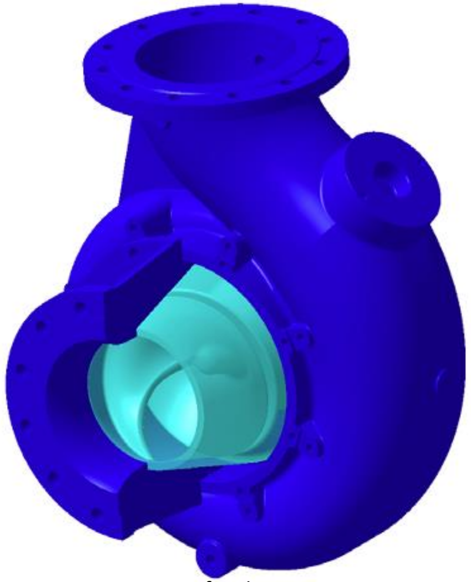


Figure 3. Centrifugal Screw Pump (Jackson)

Implementing centrifugal screw pump-as-turbine (PAT) in micro hydropower development

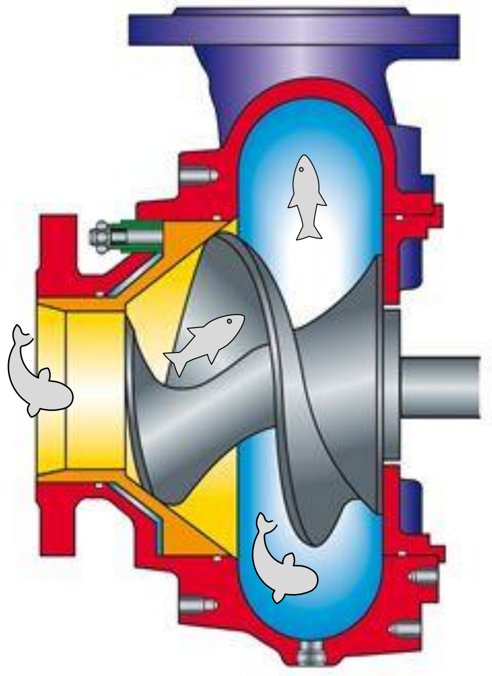
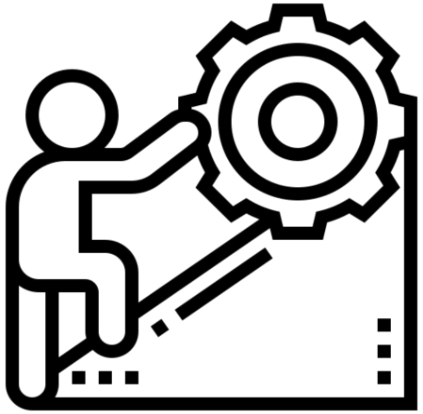


Figure 4. Fish-friendly Centrifugal Screw Pump (Process Industry Forum)

- Already proven as a fish-friendly pump
  - Allowing fish migration
- Preserving connectivity in the waterways without fully removing the barriers
- Supporting EU target of achieving 42.5% renewable energy by 2030

Research Challanges



Challenges

- The performance of the centrifugal screw pump when operating as a turbine is still unknown.
- No research has been conducted on this topic yet

Research Objective

Evaluating centrifugal screw PAT performance using Computational Fluid Dynamics (CFD)

Methodology

Geometry Modelling

- Autodesk Fusion 360
- Autodesk Inventor 2023

Computational Fluid Dynamics (CFD)

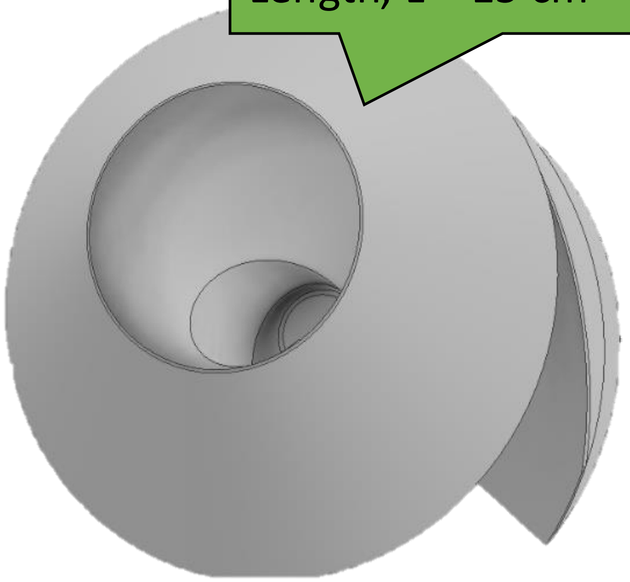
- Meshing
- Validation
- Turbine Mode Set-up

Ansys Workbench 2022 – Ansys CFX

Performance Analysis

Geometry Modelling

Inlet Diameter, $\O_{in}$ = 15 cm
Outlet diameter, $\O_{out}$ = 7.5 cm
Length, L = 15 cm

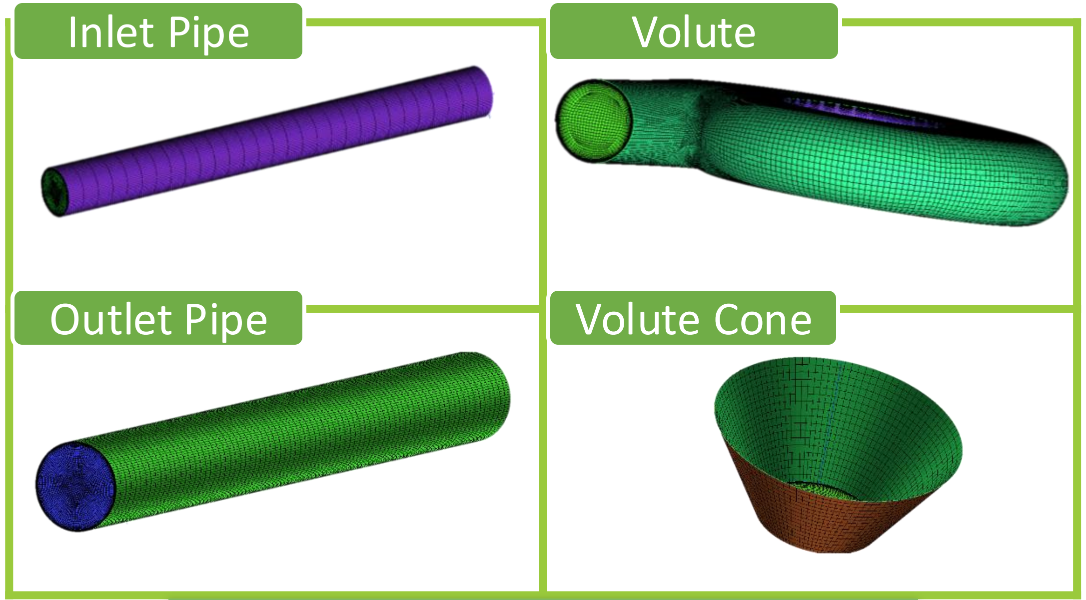


Impeller

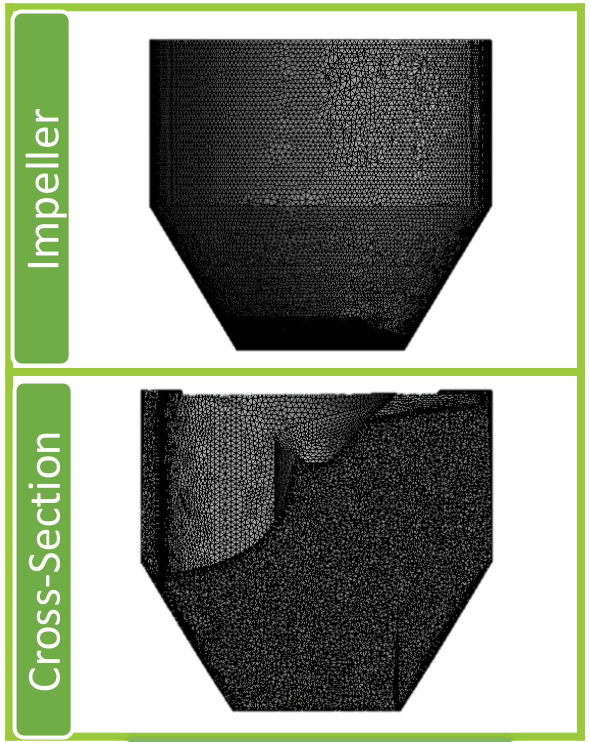
Volute

Interreg Atlantic Area
HY4RES
Co-funded by the European Union

CFD Meshing

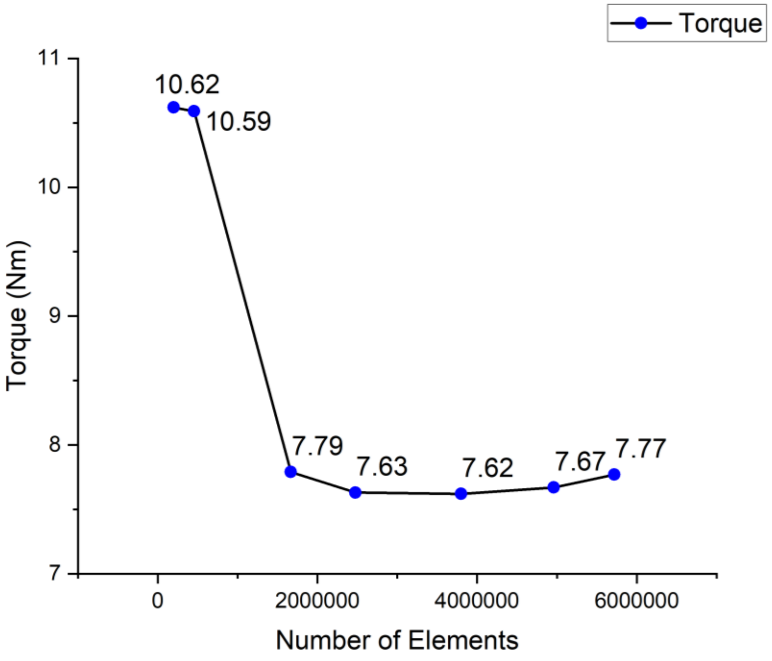


Stationary Domain



Rotary Domain

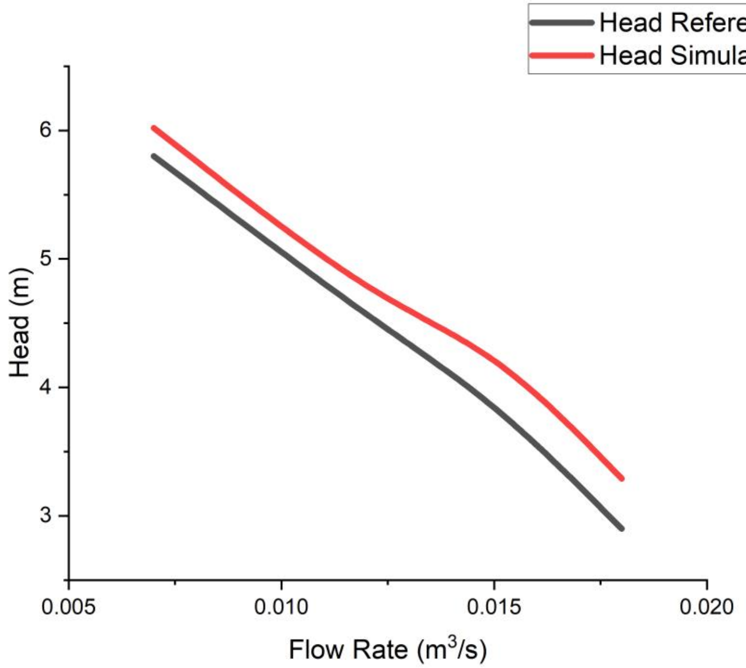
Mesh Convergency Test

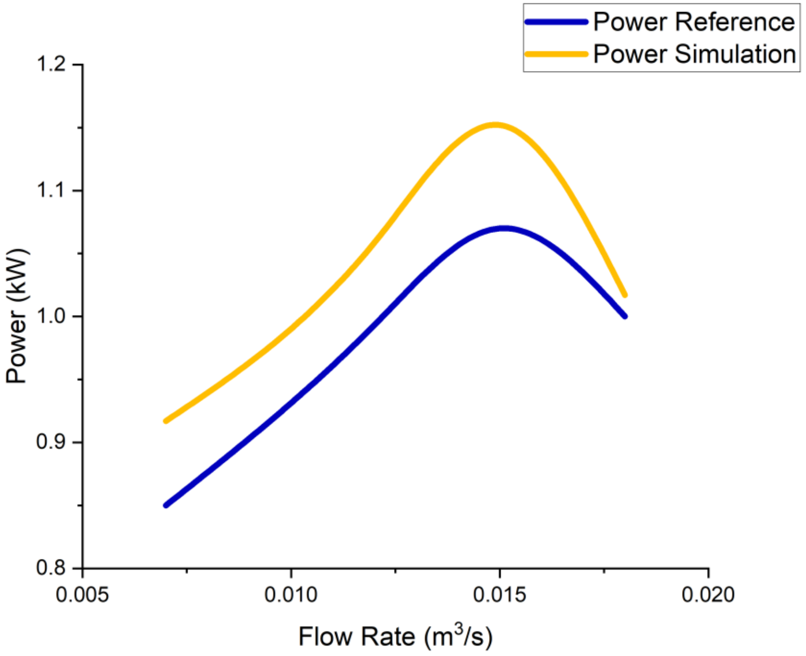


Parameters:
Inlet: mass flow rate 30 kg/s
Outlet: Opening static pressure 1 atm
Rotational speed: 500 RPM

CFD: Validation in Pumping Mode

1445 RPM





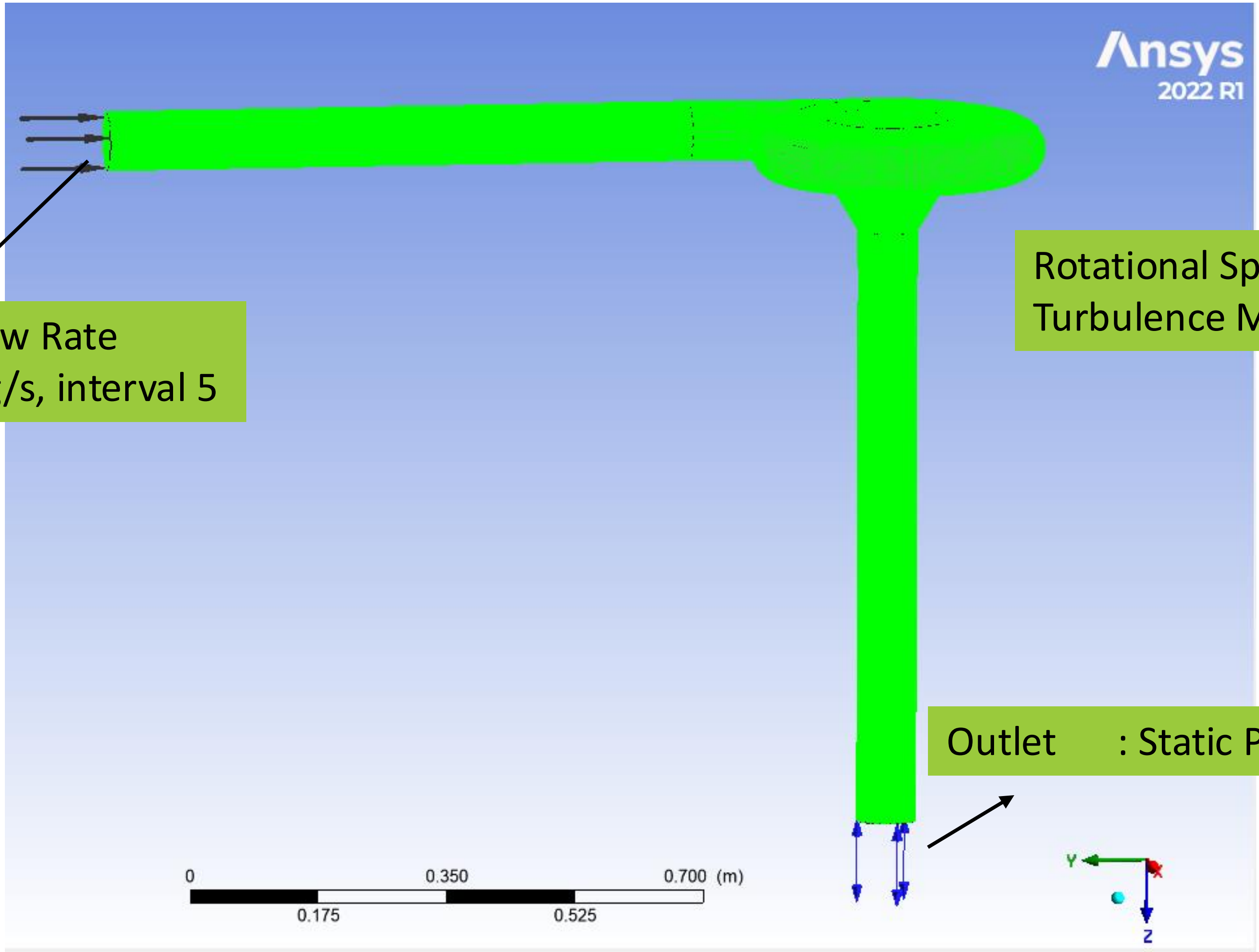
	NRMSE
Head	7.37%
Power	6.45%

Error sources:

- Bearing losses and oil losses were not considered.
- The geometry is not 100% precise, and some simplifications have been made.

Interreg Atlantic Area
HY4RES
Co-funded by the European Union

CFD: Turbine Mode Set-up

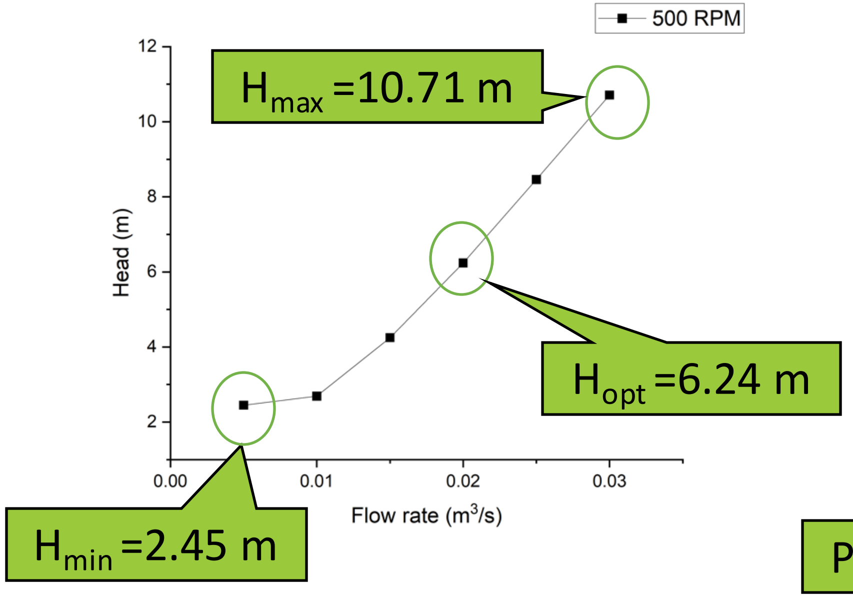


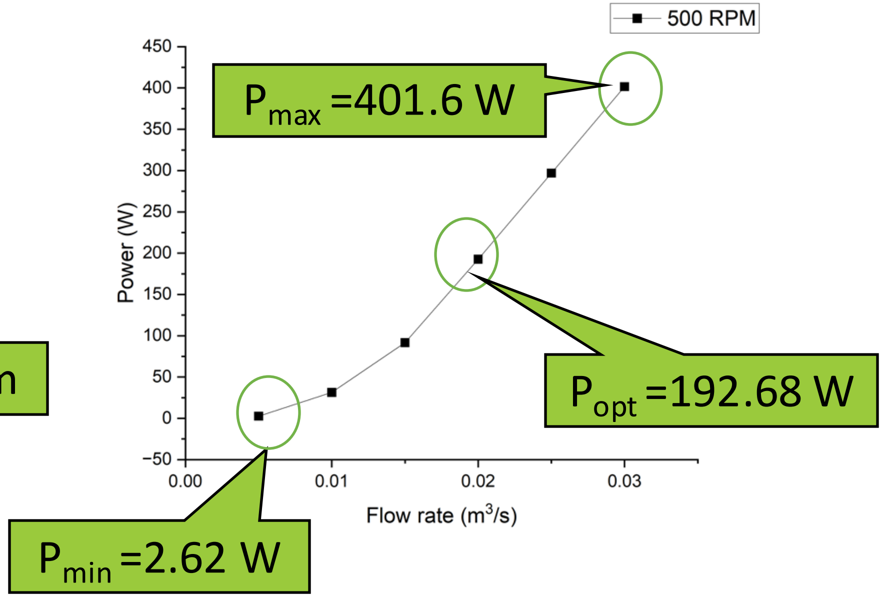
Inlet : Mass Flow Rate
5 – 30 kg/s, interval 5

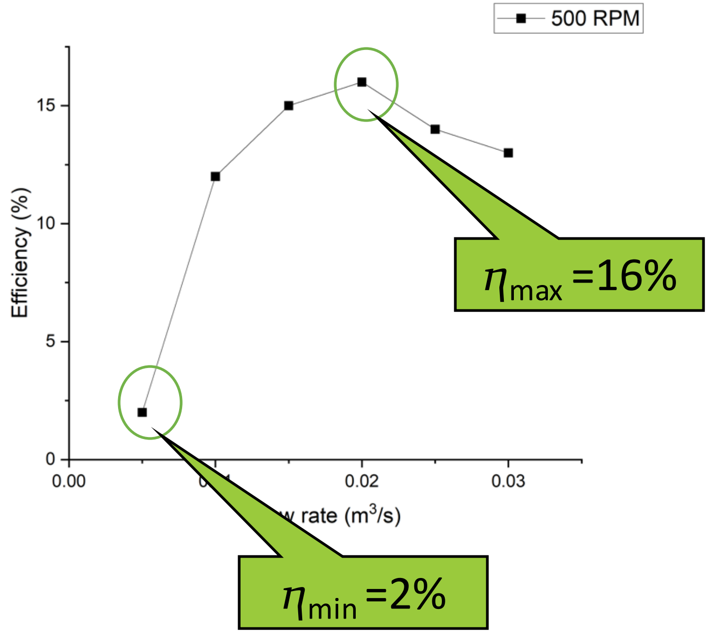
Rotational Speed : 500 RPM
Turbulence Model : SST

Outlet : Static Pressure 1 atm

Result: Performance Analysis





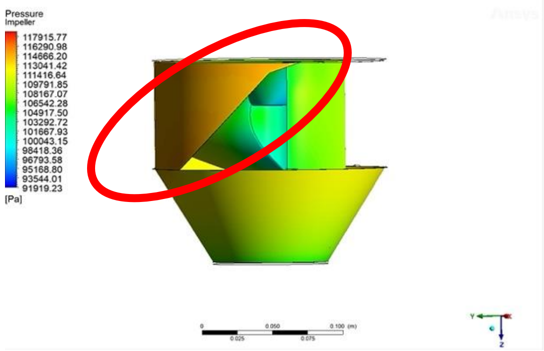


Interreg Atlantic Area HY4RES

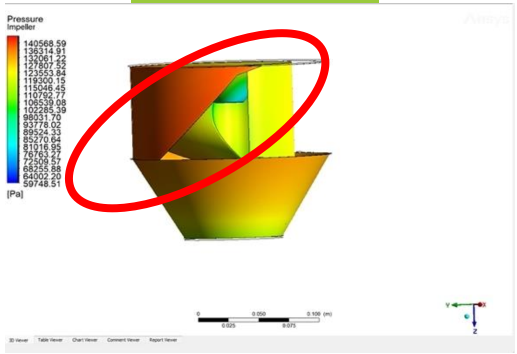
Co-funded by the European Union

Result: Pressure Distribution at Optimum Performance

Q = 5 L/s



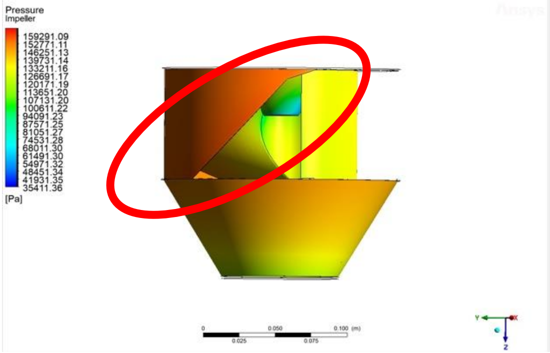
Q = 15 L/s



Q = 25 L/s

Q = 10 L/s

Q = 20 L/s



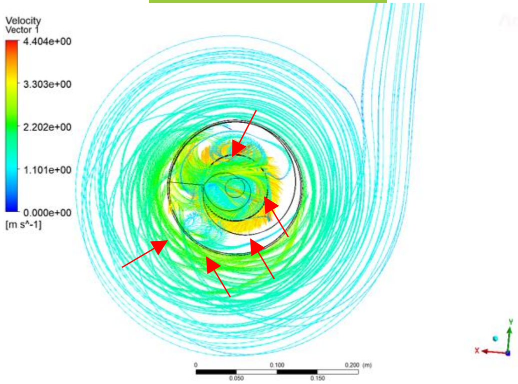
Q = 30 L/s

The pressure distribution with the highest value is on the outer shroud wall.

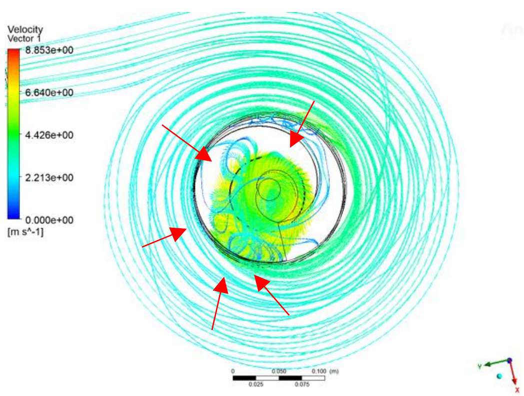
Interreg Atlantic Area
HY4RES
Co-funded by the European Union

Result: Velocity Streamline at Optimum Performance

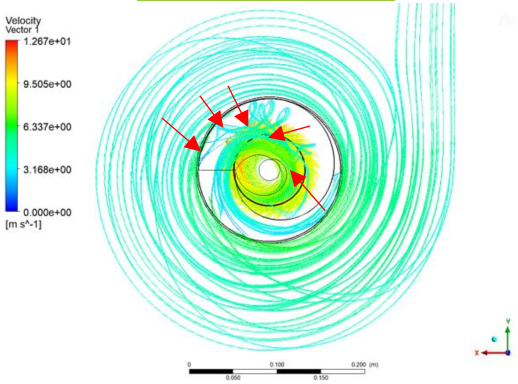
Q = 5 L/s



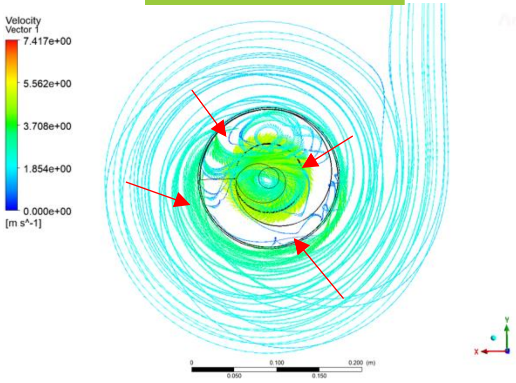
Q = 15 L/s



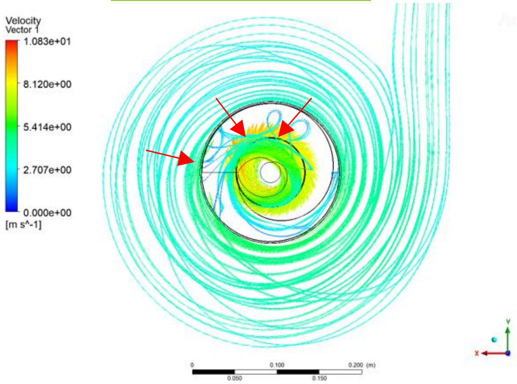
Q = 25 L/s



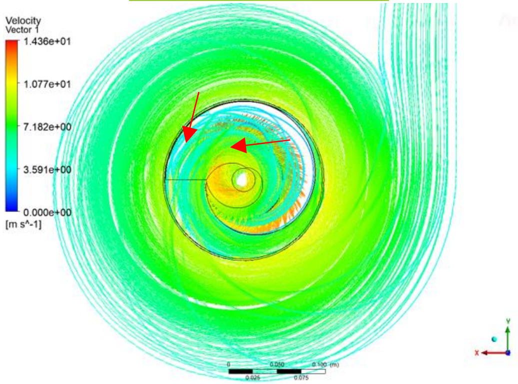
Q = 10 L/s



Q = 20 L/s



Q = 30 L/s



At flow rates of 5, 10, 15, and 25 L/s, vortices were observed, with higher intensity compared to 20 L/s

Summary

Centrifugal screw pump can operate as a turbine at 500 RPM with an optimum efficiency of 16%

Potential alternative technology to balance nature restoration and hydropower production.

Optimum power is 192.68 W, operating at a head of 6.2 m and a flow rate of 20 L/s, for smallest unit.

Higher pressure at the outer shroud compared to the impeller, the vortex flow created, and the small impeller size are factors contributing to the low efficiency.

Several analyses will be conducted for different boundary conditions and larger geometries.

Interreg
Atlantic Area
HY4RES

Co-funded by
the European Union

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

UNIVERSIDAD
DE
CÓRDOBA

AC3A
ASSOCIATION DES CHAMBRES D'AGRICULTURE DE L'ARC ATLANTIQUE

Universidad de Oviedo

FERAGUA
Asociación de Comunidades
de Regantes de Andalucía

EasyHydro

TÉCNICO
LISBOA

IG Energy

VERTIGOLAB
ECONOMIE & ENVIRONNEMENT

Interreg
Atlantic Area
HY4RES

Co-funded by
the European Union

BLUE AND GREEN
ENVIRONMENT

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

THANK YOU !