New Energy's Hydrokinetic River Turbine's Power Generation During Turbulent Flows

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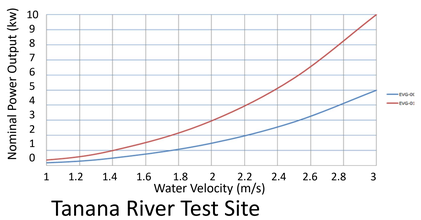
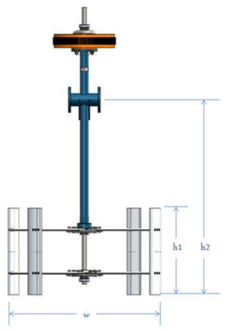
Objective

Use data from Tanana river test site in Alaska to determine the effect of turbulence on hydrokinetic river turbine energy production.

Introduction

Turbine Specifications:
Manufacturer: New Energy
Nameplate Power: 5kW
Orientation: Vertical axis





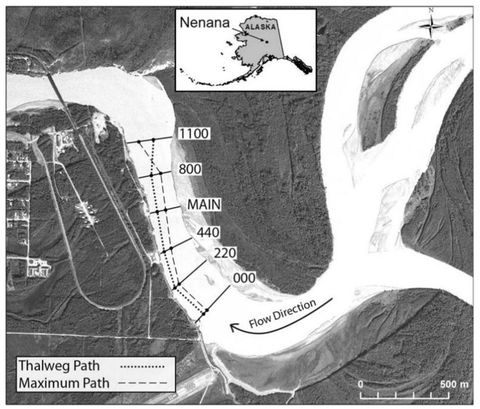
h1 = 1.5m
w = 1.5m

Tanana River Test Site

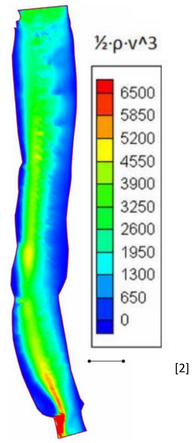
Location accurately represents Alaska rivers due to:
- Large frequency of debris
- Sediment laden

[1]

Prior Work



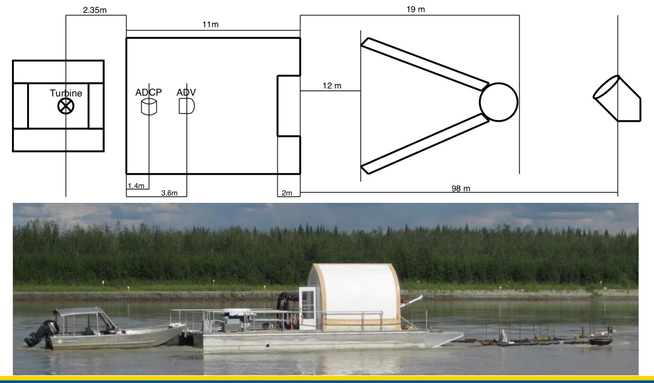
Test site is located between transects 440 and 800



[2]

Experimental Setup

5 kW Barge Main Barge RDDP Mooring Buoy



Computational Setup

ADCP Data Requirements:

Filtering Data	
Variable	Minimum Value
Correlation	30 counts
Percent Good	25%
Non Interpolated Data	90%

Turbulence Tilt Corrections Equation:

$$\theta = \tan^{-1}\frac{\overline{w}}{\overline{u}}$$
$$w' = -u * \sin\theta + w * \cos\theta$$
$$u_h = u * \sin\theta + w * \cos\theta$$

$$\varphi = \tan^{-1}\frac{v}{\overline{u_h}}$$
$$v' = -u_h * \sin\varphi + v * \cos\varphi$$
$$u_{tc} = u_h * \sin\theta + v * \cos\theta$$
$$u' = u_{tc} - \overline{u_{tc}}$$

Kinetic Power

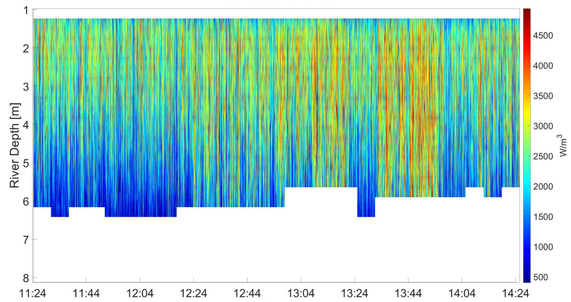
$$\frac{P}{A} = \frac{1}{2}\rho V^3$$

$$V = \sqrt{u^2 + v^2 + w^2}$$

Variable	Definition
θ	Horizontal tilt correction
u	North Velocity
w	East Velocity
v	Vertical Velocity
φ	Vertical tilt correction
P	Power
A	Area
ρ	Density of Water

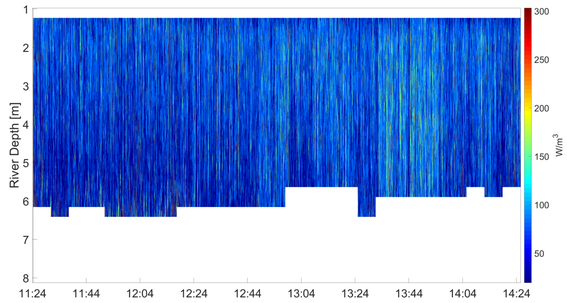
Results

Total Power



Min: 0
Mean: 2494 W/m^2
Max: 26922 W/m^2

Turbulent Power



Min: 9.5 W/m^2
Mean: 98.7 W/m^2
Max: 7257 W/m^2

On average 40% of fluid flow is turbulent contributing to 6% of the available power in the river.

Future Work

- Compare voltage/current data from the turbine to available power.
- Investigate the shear force produced by the turbulence.
- Compare the effect of different axes orientations on turbine efficiency
- Calculate turbulence spectrum and analyze the turbine dynamics.
- Process the ADV data.
- Collect more voltage and structural health data on the turbines.

Acknowledgments/ References

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[1] Hansen, N., & Kent, D. (2016). Oceana In-Stream Hydrokinetic Device Evaluation.
[2] Toniolo, H., Duvoy, P., Vanlesberg, S., & Johnson, J. (2010). Modelling and field measurements in support of the hydrokinetic resource assessment for the Tanana river at Nenana , Alaska, 1127–1139.
[3] Walsh, C., Fochesatto, J., & Toniolo, H. (2011). The importance of flow and turbulence characteristics for hydrokinetic energy development on the Tanana River at Nenana , Alaska, 226, 283–299.
[4] Guerra, M., & Thomson, J. (2019). Wake measurements from a hydrokinetic river turbine. Renewable Energy, 139, 483–495. https://doi.org/10.1016/j.renene.2019.02.052