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FLOW MISALIGNEMENT – Impact on the Power Production and AEP Estimates

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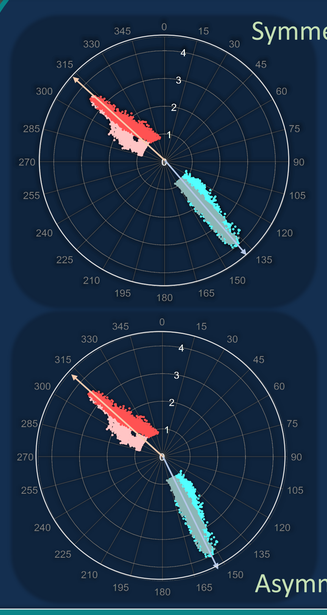
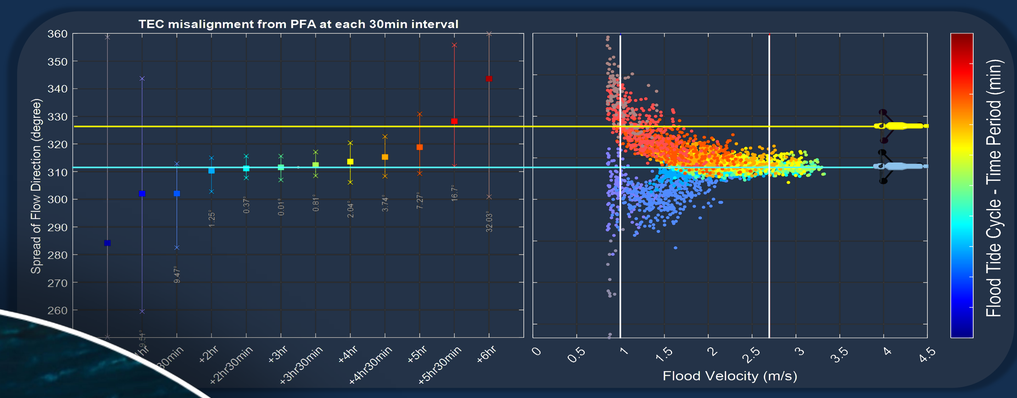
1. TIDAL FLOW VARIATION AND HOW WE MEASURE IT



- Tidal test sites suffer from both current magnitude and current direction variations. Tidal energy converter (TEC) developers deploy their device under the influence of a site characterisation carried out by Acoustic Doppler Current Profilers (ADPCs) [1]. These instruments provide current velocity and directionality data to inform developers on turbine placement and orientation.
- Some tidal characteristics make this procedure more complex due to the nature of the flow direction at the site – the uncertainty associated with asymmetrical tidal flow has been quantified previously [2,3].

2. WHAT IS VARIATION CURRENT FLOW DIRECTION?

- The current direction at energic tidal sites typically matures over the period of a tidal cycle, flowing in from a certain direction and waning out another. Therefore, TECs with no/limited yawing capabilities will be positioned to face the predominant flow direction, the impact of not facing perpendicular to the varying flow direction is examined and presented in this study.



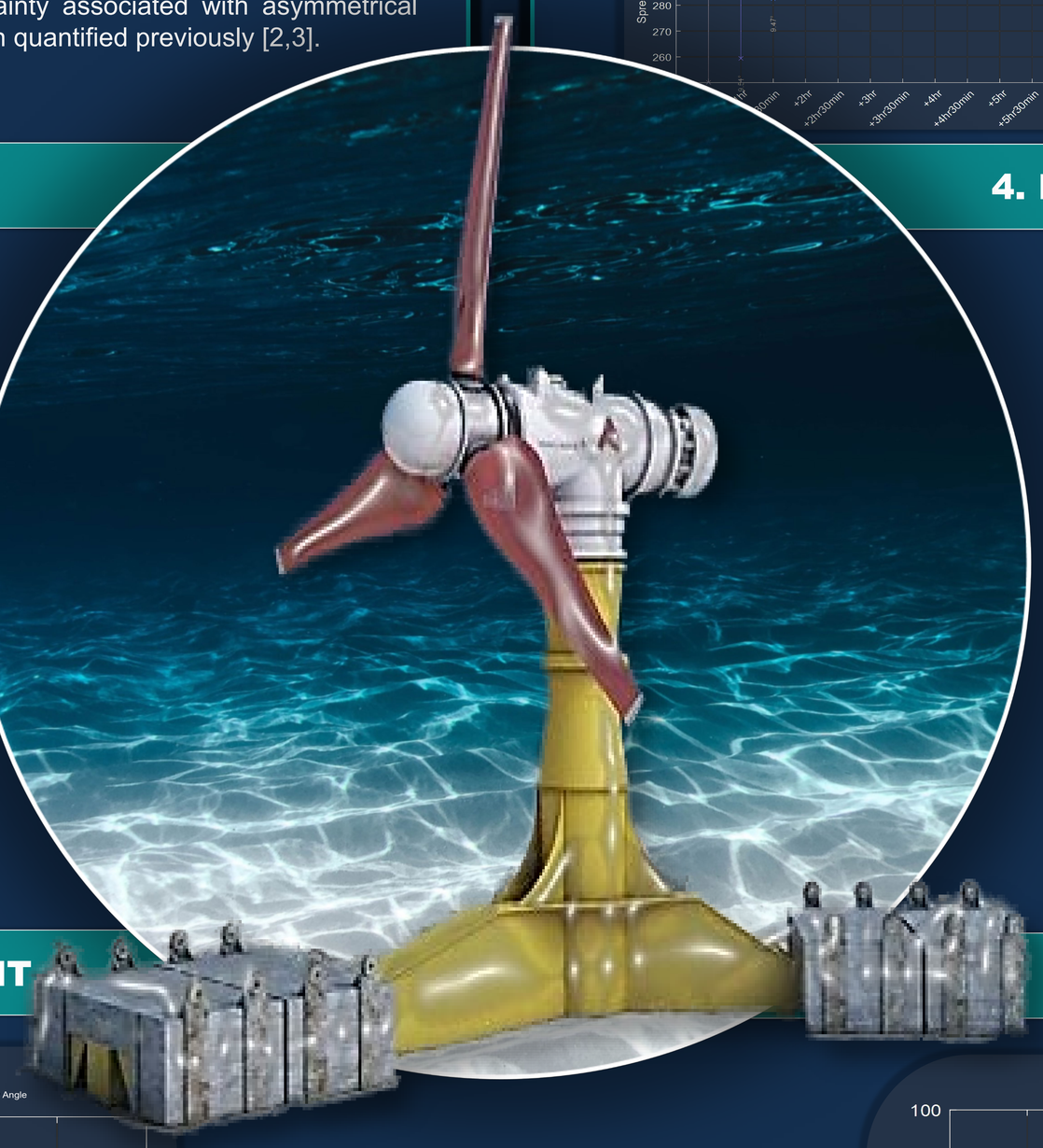
3. MISALIGNMNET METHOD

- The measured velocity for the power curve is described below if the TEC capture area is perpendicular to the free stream flow conditions:

$$V_{\alpha=0} = V \qquad A_{\alpha=0} = \pi \cdot r^2$$

- In circumstances of misalignment ($\alpha \neq 0$) the discrepancy must be accounted for. The inflow velocity (at the TEC location) and TEC capture area will now be a component of the free stream velocity as described by the following:

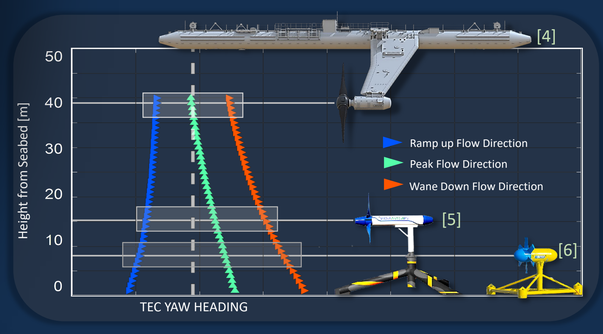
$$V_{\alpha\neq0} = V \cdot cos\alpha \qquad A_{\alpha\neq0} = \pi \cdot r^2 \cdot cos\alpha$$



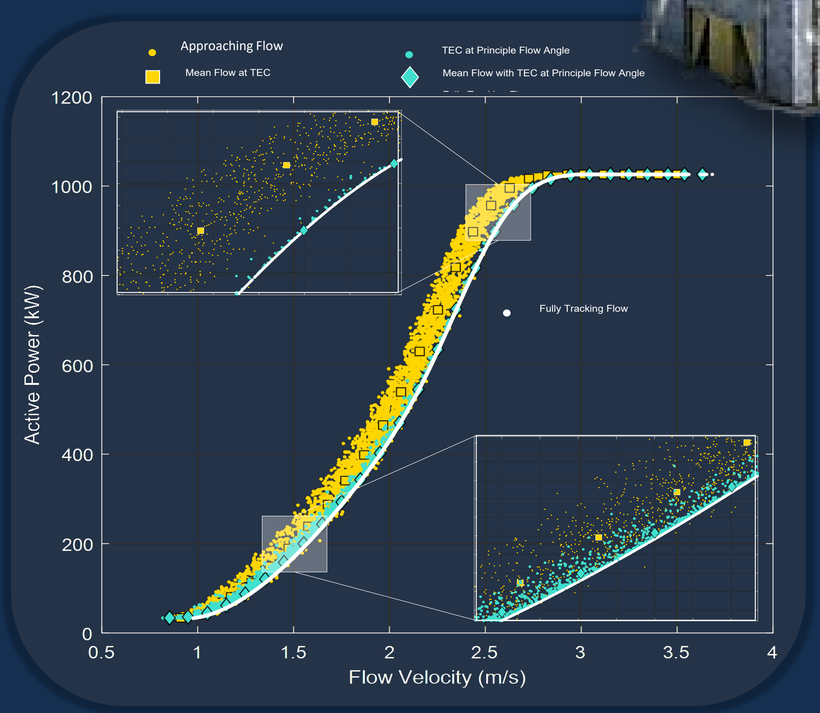
4. IMPACT ON DIFFERENT TECs

Three TEC concepts are chosen that occupy different regions in the water column:

- Flow direction varies at different depths in the water column,
- TEC operating characteristics determine how misalignment from the principle flow impacts the performance quality,
- Greater variation in flow direction is located close to the seabed due to bathymetry and seabed friction;



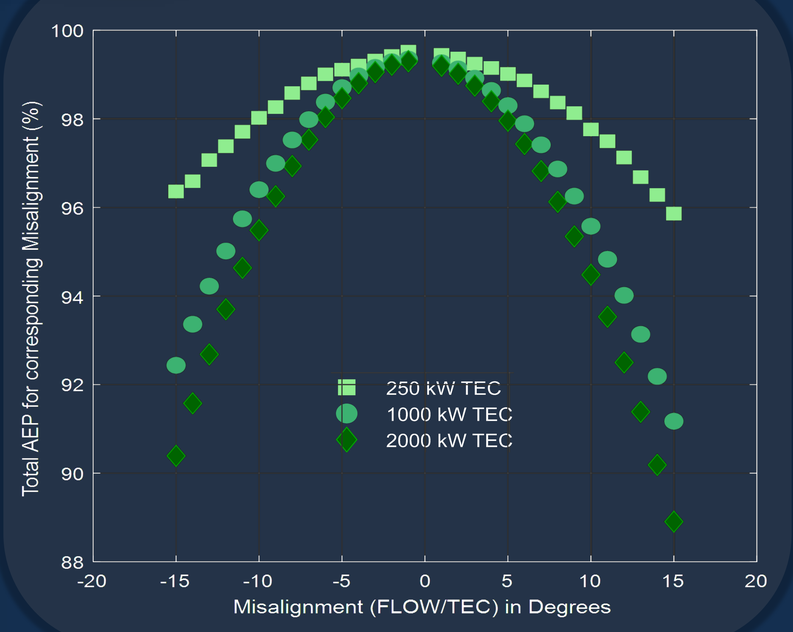
5. QUANTIFYING MISALIGNMENT



The findings demonstrate the following outcomes:

- TEC operating characteristics influence the magnitude of error when misalignment occurs,
- Neap tidal cycles have the largest impact on the power curve due to operating below the TEC rated capabilities,
- AEP differs from ≈ 0.83% from flow directional spread (assumed TEC is facing the principle flow), this increases to ≈ 12% when the TEC is positioned off-axis by up to 15°,
- Active yaw systems can aid TEC concepts when they operate beneath the rated velocity to ensure maximum energy is captured – above the rated capacity the TEC can still operate at maximum efficiency due to the surplus in velocity magnitude.

6. WHAT DOES THIS MEAN



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REFERENCES

1. International Electotechnical Commission (IEC), PD IEC / TS 62600-200
2. Tidal stream resource assessment uncertainty due to flow asymmetry and turbine yaw misalignment
3. Flow Direction Effects On Tidal Stream Turbines
4. www.orbitalmarine.com 5. www.novainnovation.com 6. www.sabella.bzh/en

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