Master-Thesis Energy and Environment

Comparative analysis of onboard renewable energy generation technologies and preliminary design for offshore mobile Energy ship

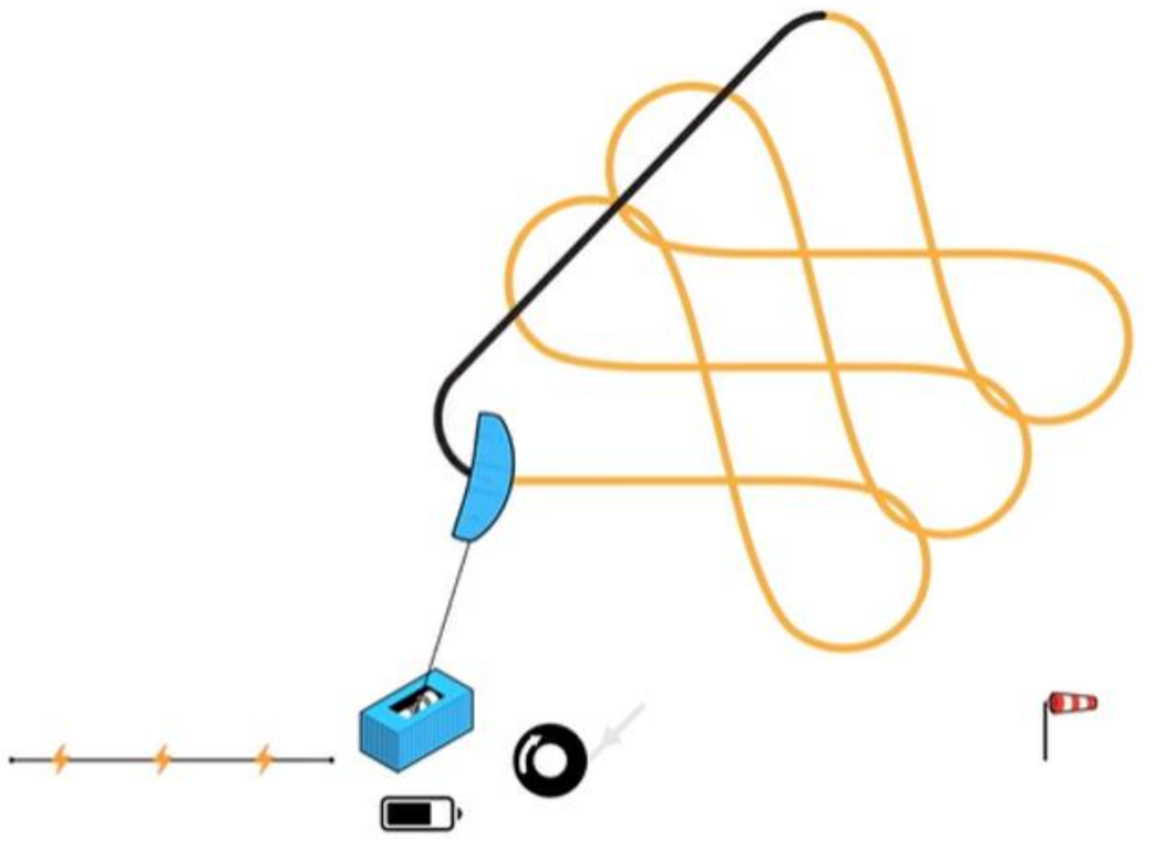

Figure 1. Pumping Kite Generator (PKG)

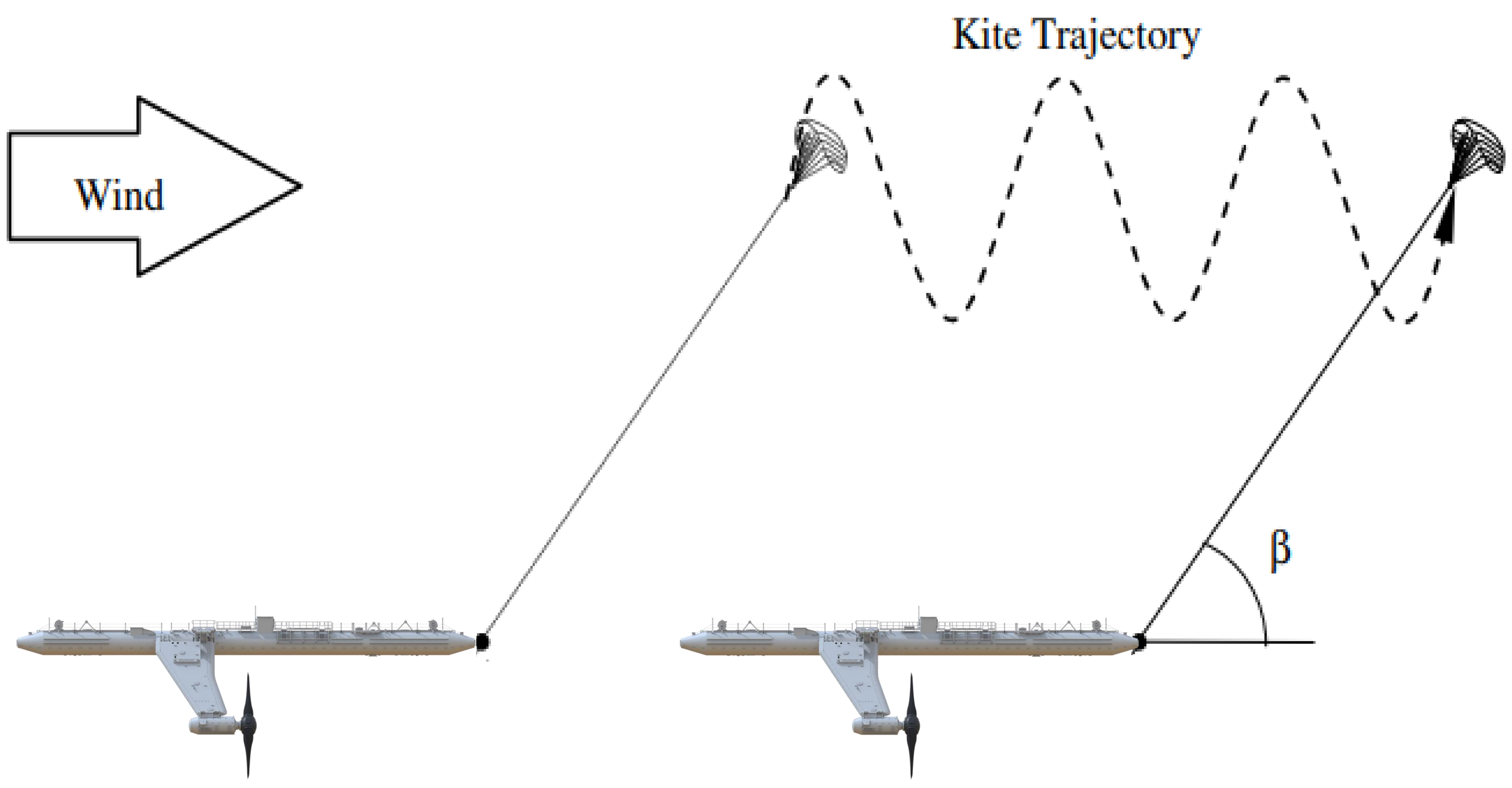

Figure 2. Kite-propelled turbine energy ship

	PKG	Turbines	Description
P_t	1119	1119	tether mechanical power [kW]
v_{hull}	5.56	5.56	boat speed [m/s]
$F_{D,hull}$	52 262	52 262	drag force on the hull [N]
$P_{D,hull}$	290.6	290.6	power lost in hull drag [kW]
P_{usable}	828	828	power available [kW]
D	0.8	n.a.	duty cycle [-]
η_{total}	0.60	0.35	overall efficiency [-]
$P_{out,g}$	629	289.9	gross power produced [kW]
$P_{reel-in}$	126	0	reel-in power demand [kW]
$P_{out,n}$	504	289.9	net power output [kW]

Figure 3. Power output results for commercial scale design

Problem and Objective

Offshore wind energy has progressed and is key to the shift toward renewables. Despite progress in floating wind turbine systems, the full potential of offshore wind remains underutilized due to the increasing challenges associated with grid connection, mooring, installation, and maintenance costs in deep waters and remote locations. To address this, mobile energy ships have been proposed.

These vessels can operate far offshore and generate renewable electricity using either airborne wind energy (AWE) systems, based on cyclic pumping kite motions (Fig.1), or submerged water turbines mounted beneath a kite-propelled hull (Fig.2).
Because they operate independently of the power grid, they store and convert energy onboard, e.g., via power-to-liquid to produce fuels like hydrogen.

Solution

This study evaluates the energy yield potential of a proposed design by comparing two energy generation technologies: pumping kite generation (PKG) and water turbines. Power outputs were calculated using two approaches: one focused on initial forces applied to the system, and the other based on the maximum theoretical limit of AWE systems.

Results

Scaled design configurations were analyzed, and their respective power outputs were assessed. The results indicate that PKG systems can offer energy production improvements of at least 42% over turbine-based designs, depending on operational conditions and design parameters (Fig.3).

The largest scale design showed annual hydrogen production rates of up to 60 tons H2/year.

Ship speed emerged as a critical variable influencing both modes power outputs. Optimal cruising speeds have been investigated, as well as crucial turbines parameters such as tip speed ratio (TSR) and optimal rotating speeds. In both configurations, mean power output scaled proportionnaly with the kite surface area.

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