Offshore Hydroelectric Energy Conversion (OHEC) Technology Overview

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Executive Summary

MacIvor Engineering presents the Offshore Hydroelectric Energy Conversion (OHEC) system — a novel, environmentally harnessed energy generation process. OHEC exploits ocean hydrostatic pressure combined with a proven gas-lift mechanism to deliver water to height, where traditional hydroelectric turbines convert gravitational potential into clean, renewable power.

Key highlights:

- Utilizes natural hydrostatic pressure from ocean depths (75m – 400m).
- Combines airlift technology and free-falling water energy conversion.
- Achieves net-positive energy production.
- Scalable for offshore renewable energy generation.

System Overview

OHEC integrates two independent processes:

1. **Water Lifting:** Utilizing compressed air injected at depth to lift water to height via density modification.
2. **Hydropower Generation:** Capturing energy from the free fall of elevated water using a Francis turbine.

Both techniques are based on established engineering principles but combined in a novel offshore application to capitalize on the ocean's natural hydrostatic pressure.

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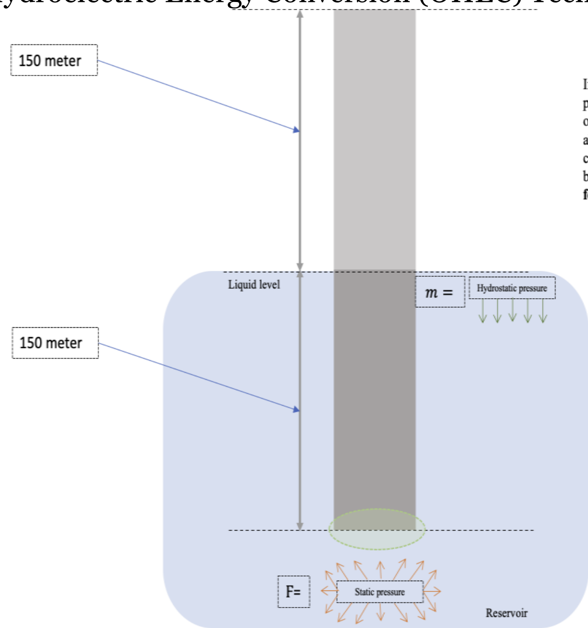

If we submerge a pipe into the sea at 150m depth, the pressure at the bottom of the submerged pipe would be over 227 psi. This is due to the mass of the water above this point forcing down. The pressure force is called **hydrostatic pressure**, which, just like the balloon when inflated and at rest, is a **potential energy force**.

To understand the first process of lifting water, first imagine a cross section of the riser at its inlet (at a water depth of 155 meters). The riser is surrounded by static pressure created by the hydrostatic pressure of the weight of the water with the gravitational force applied at the bottom of the ocean's depth. By injecting initial gap in the riser created by the injected gas pressure. This hydrostatic pressure will rush in to fill the void. Once this hydrostatic water inside the riser is in motion, it becomes a hydraulic force of water rushing into the piping system. As a result of injecting air bubbles, the hydrostatic pressure will continue to refill the vacancy caused by the water that is rising due to the high velocity and density change in the mixture of fluids. This method creates a pump behind an air lifting system, making the gas lifting method effective. Gas lift systems have been around for a very long time; however, they are not efficient without this hydrostatic pressure forcing the water to the injected gas.

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Identifying Types of Energy

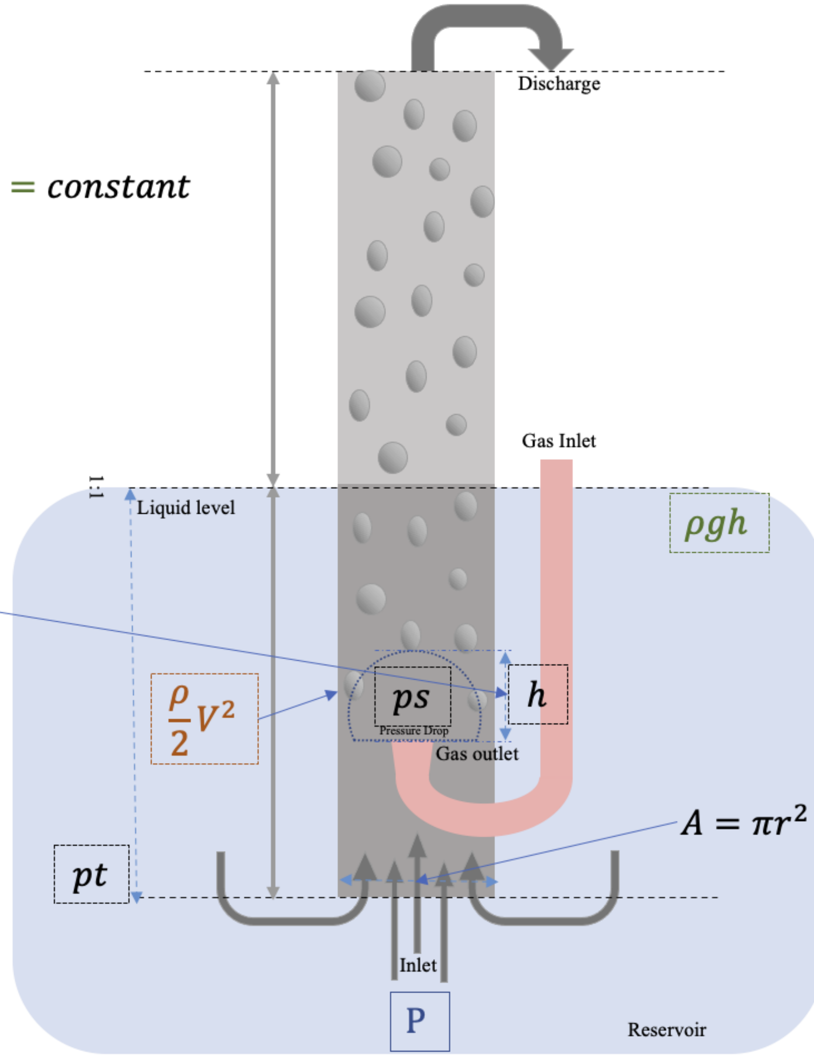
Static Pressure + Dynamic Pressure + Hydrostatic Pressure

$$P + \frac{\rho}{2}V^2 + \rho g h = constant$$

Pressure Energy + Kinetic Energy + Potential Energy

Conservation of Energy

The area created by the injected gas transforms the static pressure to dynamic pressure by the pressure change, accelerating the fluids. The acceleration multiplies the mass of the water entering the pipe and creates a kinetic force. This kinetic force (g) + the kinetic force (L), adds to the buoyant forces to lift the water up the water column.



How does gas or air lift the water?

In the vertical riser, the mixture has two distinctly different properties. One being a compressible component (air), and the other being the non-compressible component (water). The two components will react differently under pressure, thus changing the density as the mixture travels up the riser. As the mixture pressure drops when it travels up the riser's vertical distance, the density decreases while the velocity increases.

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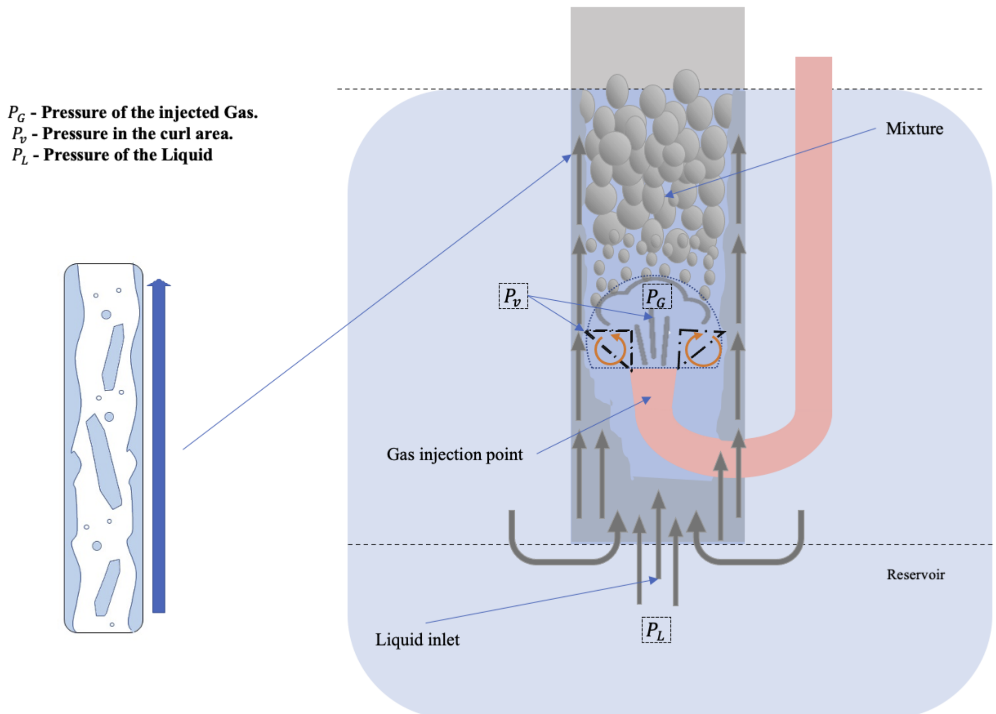

It is important to note that when the mixture moves through a full pipe, the volume of fluid that enters the pipe must equal the volume of fluid that leaves the pipe, even if the diameter of the pipe changes. Our models and testing show that the water is less dense at the outlet than at the inlet, affirming that the density changes as the mixture rises through the riser and the entrained air expands. Although this demonstrates that the water will rise, it's more important to show the momentum of these fluids when determining the amount of water that is produced at the top of the water riser. The law of conservation of momentum states that the momentum of an isolated system remains constant. Momentum is therefore said to be conserved over time; that is, momentum is neither created nor destroyed, only transformed, or transferred from one form to another. This explains that after the fluids are worked through the slug regime and into the bubble regime, the slip will be closer to a 1:1 ratio. This ratio of 1:1 applies the momentum of the air to the water during the lifting process and produces a high flow rate. This slip ratio is achieved at these velocities from the high rate that the water is entering the inlet, thus creating an efficient airlift system, only due to the hydrostatic pressure of the sea. The efficiency is even greater after several minutes of production due to the applied momentum.

Simply put:
The lower density of the mixture will rise up the pipe, becoming in motion. Once in motion, the momentum of the hydrostatic pressure of the water forces the water to rush into the pipe and the momentum of air injected into the pipe, creating a less dense mixture than the water created the mixture to rise at a rapid rate. This makes for a very effective airlift system from the rushing force of the water inlet.

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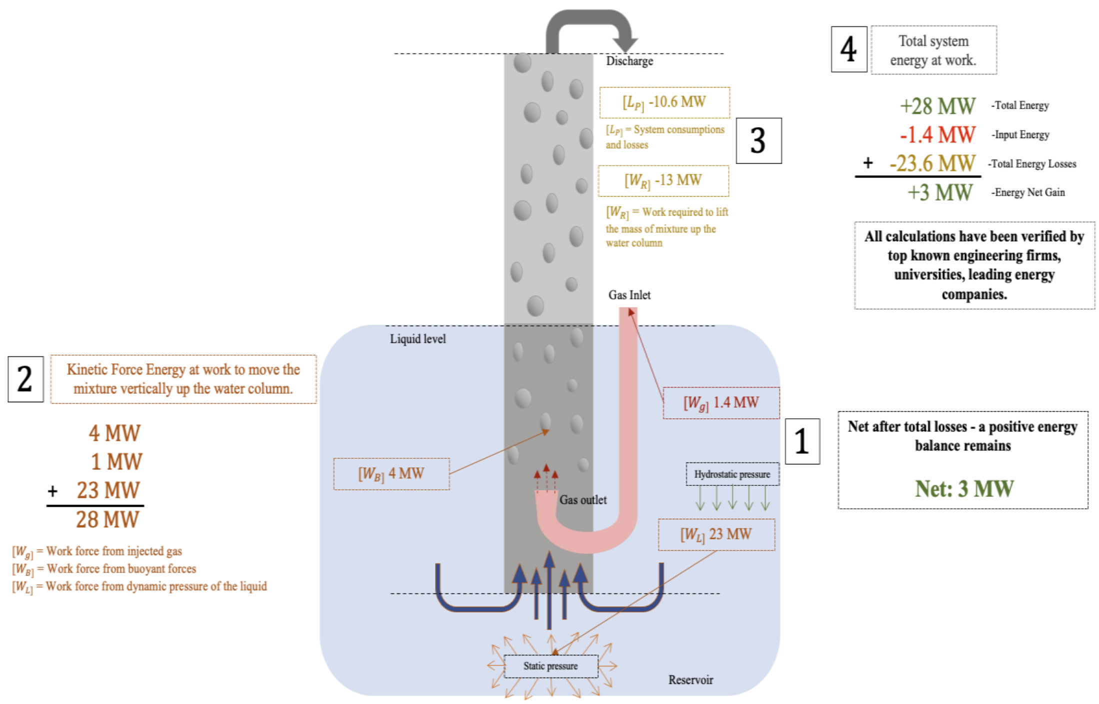

More information on two-phased flowing: https://www.sciencedirect.com/topics/engineering/two-phase-flow

Energy used:

To explain the energy balance, it first has to be understood that these two processes of lifting water and falling water are not related when it comes to comparing energy balance.
In layman's terms, the equation can be written:

Air compressor energy consumption + hydrostatic pressure at riser inlet = hydroelectric power generation because of free-falling water captured by a Francis water turbine

As a result of the hydrostatic pressure aiding the lift of the water to the top of the risers, the power consumption required from the air compressors is significantly less than the power generated by the Francis water turbine.
The pumping of the water up the water risers, also called the "pumping process", gains the work from the air compressors, plus the external forces (hydrostatic pressure). Therefore, the electricity production process reduces the consumption of energy used by the air compressors.

The "pumping process" requires 1.19MW of electrical force to pump air to the depth of the inlet and to produce the required air pressure and volume. The hydrostatic pressure provided by the sea provides 1.88MW of hydraulic force.

1.3MW + 2MW = 3.3MW used to move 2.6 m3/s of water to the top of the water riser.

Where we end up:

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The main goal is to answer the question: How much water makes it to the top of the riser? Several tests and different models have shown and calculated that 2.6 m3/s of water will reach the top, and the air is returned into the atmosphere.

If we know that 2.6 m3/s of water is at a known height, we can easily determine the electrical output of a standard hydropower system. Using standard hydropower practices, the falling water gains the G-factor needed to produce 3MW of electricity.

These projections are considering all the losses of the entire system.

More information on hydropower calculations: https://www.engineeringtoolbox.com/hydropower-d_1359.html

Technical Conclusion:

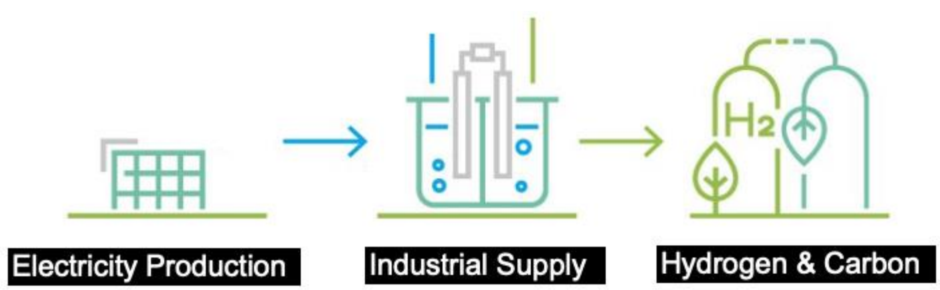
In conclusion, the airlift system uses OVER 3.3MW to produce ONLY 3MW. Due to the added hydrostatic pressure not having to be provided to the system, we have a net gain of power. When reviewing the overall system efficiency, it was found that the system itself is not efficient; It is only effective because we gain back the energy consumed in the airlifting process, including the forces provided by the hydrostatic pressure. This grants the positive net gain of power while also supplying an overall positive energy balance.

We are simply reverse syphoning the water to the top of a pipe and making a waterfall offshore.

Technology Uses:

The technology can be used to provide the energy sector 0 carbon production of truly sustainable energy. Providing cities and industries a true stable energy source.

- Hydrogen production
- Base load power
- Electrical generation
- Carbon Capture
- Industrial supply



1.1 REVISION HISTORY

Pub. Date	Rev #	Request ID	Description
12/18/2019	01.00		Initial Publication. The Executive Summary addressing this development of this standard can be found at LINK.
02/10/2022	02.00	CR# 111	Update terms