

THE CLEAN SUSTAINABLE ENERGY CARRIER



SIMULTANEOUS
PRE-TREATMENT
AND
ENERGY EXTRACTION
FROM
HYDROGEN SULFIDE (H_2S) IN WASTEWATER

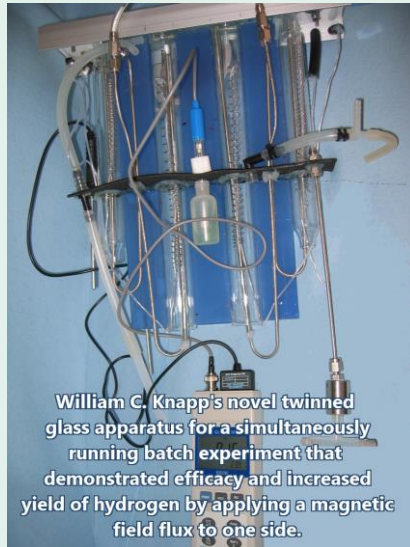
Opportunity for EQUITY PARTNERSHIP

- Wastewater treatment plants are under increasing pressure to become “energy positive” in addition to facing increasing environmental regulations.
- Current solutions are based on recovering biogas from digestion. Unfortunately, that produces methane CH_4 plus equal amounts of CO_2 . That is followed with combustion of the CH_4 which creates CO_2 emissions; negating any energy benefit for the community.
- Hydrogen Sulfide (H_2S) is a naturally-occurring gas produced by bacteria in anaerobic environments. When oxygen is present H_2S forms sulphur dioxide SO_2 which in three steps forms sulphuric acid H_2SO_4 that destroys wastewater infrastructure.
- **A New approach:** The Knapp Process will enable a wastewater plant to extract hydrogen directly from dissolved hydrogen sulphide ($\text{H}_2\text{S}_{\text{aq}}$) in the wastewater stream while *simultaneously* improving the treatment process and, by reforming H_2S before it forms H_2SO_4 and thereby significantly reduces costly infrastructure replacement.

A Novel Approach...

- Electrolysis is typically used to extract hydrogen from **water (H_2O)**. However, renewable energy required to break the **H_2S** bond is lower (**381 kJ/mol**). than renewable energy required to break the **H_2O** bond being (**486 kJ/mol**). Net **positive energy** yields by targeting **H_2S** than **negative energy H_2O** .
- In addition to applying the proven process of electrolysis to his target *Dissolved* hydrogen sulfide (H_2S) he subjected the cathode to a NOVEL TECHNIQUE which significantly increased the yield of hydrogen.
- The “Knapp Process (patent pending) applies the demonstrated process of a combined electrolysis & novel technique to extract hydrogen from dissolved hydrogen sulfide (H_2S). The inventor Knapp is a retired 35-year veteran of Dupont Canada’s Research & Development Centre
- This patent pending “Knapp Process” is able to produce Hydrogen from ubiquitous dissolved hydrogen sulfide, yielding both a zero-carbon fuel for fuel cells while also ***simultaneously*** reducing H_2S to a benign by-product which renders an overall reduction in wastewater treatment costs.

Proprietary Technology: The “Knapp Process”

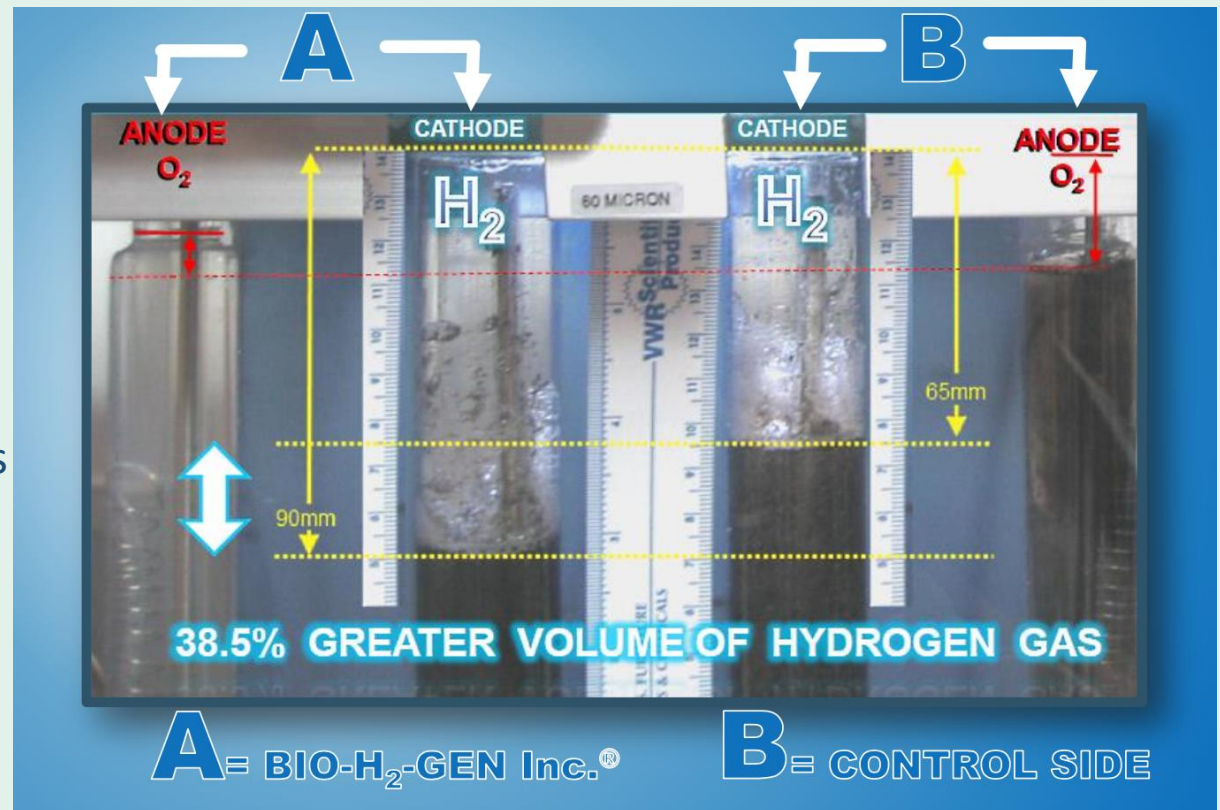


The proprietary modification, to a conventional electrolysis process, uses a novel technique to improve process yield by **over 38%.**

**A ZERO-CARBON
PROCESS**

THE NOVEL BATCH EXPERIMENT APPARATUS THAT VALIDATED KNAPP'S HYPOTHESIS USING A NOVEL TECHNIQUE.

The result of the novel technique was depicted in a batch experiment using a twinned glass apparatus shown on the left.



Electrolysis of H_2S is a “Game Changer”

Utilities can reduce biological & chemical oxidation costs (BOD & COD) while simultaneously adding the benefit of producing **hydrogen** the “zero-carbon” energy carrier.

- Rapidly develop an on-site energy generation capability – produced energy can meet other utility needs including zero-carbon electric vehicle fuel.
- Potential for reduction of H_2S formation in wastewater collection network where corrosion is a major issue and cost.
- Leverage incentives provided by carbon cap-and-trade and emission reduction programs.
- Reduce downstream treatment energy consumption due to lower aeration energy costs.
- Reduce potential for corrosion damage to expensive wastewater collection infrastructure by locating electrolysis points within the collection network.

Progress to Date

- **Lab-scale prototype developed:**
A twinned simultaneous experiment provided a successful comparison of the “Knapp Process” novel technique influence to the identical control side.



SMALL LABORATORY BUILT TO CONDUCT THE EXPERIMENT

Patent applications filed:

“Method for Producing Hydrogen Gas from Aqueous Hydrogen Sulfide”

- **US Provisional patent application:** Date of filing: June 19th, 2015
 - **Patent Cooperation Treaty Application (PCT)** Filed.
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- Next step is an engineering firm will be engaged for our modular pilot plant that will include in-line process design and package pilot plant design. They provide a “turn-key” operation that includes testing as well as delivery, set-up and training.
 - Receipt of the “turn-key” tested pilot plant will greatly facilitate country-wide implementation of the added “Knapp Process”.

Market Opportunity for the “Knapp Process”

- The US alone has 14,748 wastewater treatment plants and Canada, in 1992, was known to have 2,800. The worldwide market would add tens of thousands more.
- Additional markets include:
 - ✓ Industrial wastewater treatment facilities.
 - ✓ Large scale animal farming waste lagoons.
 - ✓ Breweries, commercial juice production and food processing wastewater.
 - ✓ Centralized locations of *massive sources of H₂S*; e.g. The Dead Sea contains trillions of kilograms of dissolved H₂S in its anaerobic depths.
- Source of *differentiation* for wastewater treatment system concession operators – They are able to offer:
 - 1) greenhouse gas reduction impact,
 - 2) reduce vehicle fleet carbon emissions,
 - 3) reduce energy consumption
 - 4) and dramatically reduce infrastructure repair costs.
 - 5) Reduction in biological & chemical oxygen demand. (COD & BOD costs)

Development Strategy

- Design a standardized modular “package plant” that can be deployed at even small wastewater treatment facilities to support waste-to-energy extraction with simultaneous reduction in H_2S treatment costs.



An example of a modular pilot plant. Our selected Canadian engineering firm designs them to fit on a flat bed transport for delivery.

Future Requirements

We require a strategic partnership/investment to:

- Develop prototype modular packaged pilot plant to demonstrate batch-to-inline scale-up, process yield increase, lower effluent treatment costs. Can leverage potential grants from several organizations.
- Capital & operating expenditures [CapEx & OpEx] are estimated at ~\$3.5M (USD) for delivery and operation for 2 to 3 years. Marketing engineering data, for scale-up, expected within that timeframe.
- OpEx support will also enable international-phase patent filings.
 - We will select countries for patent application filings to receive patent cooperation treaty (PCT) date protection from June 19th, 2015. Legal fees estimated to be ~\$ 50K (USD).
- Select initial pilot plant demonstration site(s).
 - The selection could also serve as a research and development centre for process optimization and the incorporation of further cost cutting innovations.
- Design-build-operate (DBO) of package plants in staged global rollout.

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An Ontario Canada corporation



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THANK YOU

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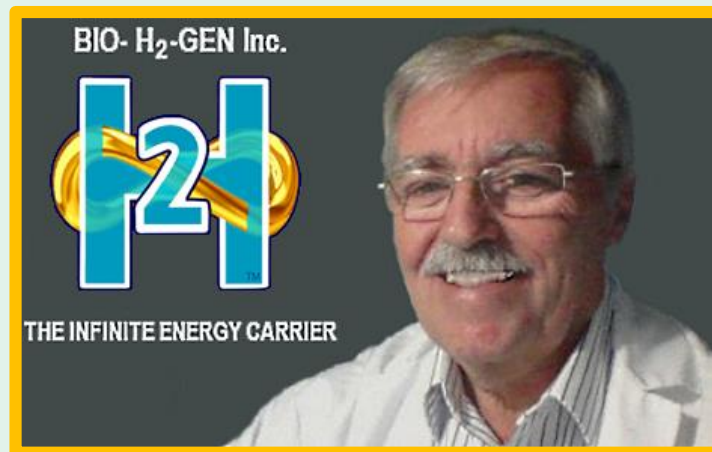
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THIS “ROCKET” STILL HAS SOME BOARD ROOM