

EFFICIENCY ASSESSMENT REPORT

MRE HYDROGEN GENERATORS

Efficient generation of Hydrogen to provide a cost effective fuel and energy storage.

Solution ID: 12184

Company: Millennium Reign Energy, LLC

Country: United States

Export Date: 23.11.2020

ASSESSMENT RESULTS



APPROVED

FEASIBILITY

- Credibility of concept	YES
- Scalability	YES

ENVIRONMENT

- Environmental benefits	YES
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PROFITABILITY

- Client's economic incentive	YES
- Seller's profitability	YES

GENERAL COMMENTS FROM THE SOLAR IMPULSE FOUNDATION

The Solution is awarded the Solar Impulse Efficient Solution as:

- **It is fully satisfying the Eligibility Criteria** in terms of: (1) Nature of the Solution namely, physical/financial product, technology, industrial process, or service; (2) Ownership by a Member of the World Alliance for Efficient Solutions; (3) Contribution to at least one of the Sustainable Development Goals (SDGs), namely SDG 6, SDG 7, SDG 9, SDG 11, SDG 12; (4) Minimum maturity level, namely "prototype testing 1:1 in lab" (TRL 6 -7);
- **It is operating in accordance with the Solar Impulse Foundation's ethical position** as expressed by the Membership Agreement;
- **It is compliant with the conditions expressed in the "Liability Waiver Declaration"** signed by the Member in the framework of the labeling process and external reputational check;
- **It has been reviewed and pre-validated** by the Solar Impulse Foundation's team during the pre-screening stage, to ensure minimum standard of quality, in terms of relevance and completeness of the information provided in the application form;
- **It has been assigned and evaluated** according to the official "Label Standards" by three independent Experts with at least five years of Experience in one of the sectors of application of the Solution;
- **It has been assessed and formally validated (accepted)** by three External independent Experts based on the five criteria (credibility of concept, scalability, environmental benefits, client's economic incentive, seller's profitability). In particular, the three independent Experts performed valid assessments, thus provided complete and coherent answers in accordance to the official "Label Standards" and "Assessment Guidelines".
- **It received a minimum of two "YES" answers** from two different Experts on all five criteria, meaning that all the five criteria were satisfied and obtained a majority of "YES". As a result, the Solution does meet the requirements for being awarded the Solar Impulse Efficient Solution Label.

It is important to notice that, the outcome is attributed to the Solution itself and NOT to the entity submitting the Solution (the company).

FEASIBILITY

The Feasibility section is aimed at determining the technical viability of the idea behind the Solution, such as ensuring a Solution is feasible in the real world. This section is composed of two criteria and it considers: the technical requirements of the proposed Solution and captures its ability to be credible based on a resilient technology or concept (**Criterion 1**) and its potential to be technically scaled up and deployed in the real world (vs. in a laboratory environment) without additional constraints (**Criterion 2**).

EXPERTS REVIEWS

CRITERION 1 - CREDIBILITY OF CONCEPT

Can the technology behind the Solution be constructed and operated as designed?

YES

First Expert justification - MRE technology aims to accelerate the deployment of hydrogen fuelling infrastructure profitably that can scale simultaneously with demand by leveraging small, streamlined, modular design. The proposed system is fully automated and it can be powered by either the grid, wind or solar power. So, the solution could be operated as designed.

YES

Second Expert justification - Hydrogen fueling has gained significant interest since the 2015 release of light duty vehicles. Hydrogen had already gained popularity in industrial trucks (forklifts). The ability to develop an appliance which makes and dispenses hydrogen at a demonstration scale has many applications. The Solution proposed has demonstrated initial prototype and pilot plant phases of technology development TRL 4-5. The concept is credible.

YES

Third Expert justification - The technology of producing Hydrogen using the Electrolyzers, is credible and have stood the test of time (<https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis>). MRE Electrolyzers (generators), that comes in two main classes, the AutoARK (Fully automated hydrogen generator for residential, small business, telecom and farm applications) and the Scalable Hydrogen Fueling (SHFA) (for fueling stations), are safe and affordable. The technology is built with a patented membrane and Electrolyzers with models, 100, 102, 104, 200 and 300. The combination of Hydrogen generators, purifiers, compression, storage and dispensing in side the SHFA ventilated stainless steel infrastructure, has earned the innovation the a certificate of Attestation and CSA Mark confirming the equipments's safety record and credibility in USA, Canada and the EU. The issuance of trademarks on the green banner and the H2 with 3 leaves logo, further gives the solution the credibility to compete on the market.

CRITERION 2 – SCALABILITY

Is the manufacturing (if a product) or distribution (if a service) of the Solution at scale technically feasible?

YES

First Expert justification - MRE Electrolyzers are built with efficiency in mind. The systems can use waste heat for assisting in heating a home as a by-product of hydrogen production which further increases efficiency. This greatly enhances the affordability of the on-site production of hydrogen. The products meet the necessary codes and standards to be safely deployed. The products are Patented in the USA, Canada and the EU and trademarks have been issued on the green banner. The Solution is currently available in the United States and Canada. Therefore, the manufacturing of the Solution at scale is technically feasible.

YES

Second Expert justification - The solution proposed is a product. Yes, the scalability of this product is technically feasible. The Innovator provided a detailed breakdown of the source materials and parts supply which supports the assessment. It is less clear regarding the scalability of the other technical resources necessary to scale a product, e.g. intellectual

property protection, access to capital for investment, strategy for timing of 'when to scale', technical challenges to automation or high volume manufacturing.

YES

Third Expert justification - The MRE Hydrogen Generators/Stations, are built with robust materials with expected life span of 36,000 hours for the station, 25-30 years for the electrolyzer, and the chillers of 10,000 psi pressure built with moving replaceable parts. The materials used for building the MRE, are readily available and electronic components such as logic controllers, rectifiers, PLCs, VR, transformers etc available from the innovator if required. With more than 100 vendors, 96% in USA, the supply and after market services are steady and strong, hence reinforcing the scalability status.

ENVIRONMENTAL IMPACT

The **Environmental Impact section** is aimed at determining the impact of the Solution at the different phases of its lifetime: production, transportation and distribution, as well as use and disposal phase.

This section is composed of one criterion and it considers: the potential to enable a direct positive impact (**Criterion 3**) on the environment compared to the mainstream alternative identified – referring to the scope of the following elements: Energy use, CO2 emissions, Water use/materials use, Air quality, Ecosystem preservation.

EXPERTS REVIEWS

CRITERION 3 - ENVIRONMENTAL BENEFITS

Can the Solution deliver an incremental environmental benefit versus a mainstream alternative, considering the lifecycle (production, use and disposal stages) of its value chain?

YES

First Expert justification - Compared to the status quo on hydrogen production, mainly fossil fuel-based, MRE shows considerable environmental benefits. The technology is flexible and expandable. Hydrogen produced for the transportation sector by MRE can be used to supply hydrogen fuel cell (HFC) cars. A direct comparison with diesel, ethanol, petroleum, natural gas, and even electric vehicles shows a substantial decrease in carbon emissions per mile. Even though hydrogen has high environmental benefits, its current price makes it less competitive than other fuels. Electric vehicles and natural gas fuel vehicles, for example, have larger CROIs as a result of their lower costs. But when compared to the most common fossil fuels, every thousand dollars invested in MRE's technology will save four times more CO₂eq than gasoline technologies, the most commonly used fuel in the road transport industry. Therefore, the Solution can deliver an incremental environmental benefit versus a mainstream alternative, considering the lifecycle

YES

Second Expert justification - The solution provides a product which meets near term demands for electrolysis based hydrogen fueling. This product facilitates the overall clean energy transition and thus provides significant benefits versus fossil fuels. The specific lifecycle impacts of the Solution are aligned with the impacts of best in class electrolyzer systems.

YES

Third Expert justification - The LCA was done by a third part and compares the MRE technology to other Hydrogen generating systems and other fuels, on two areas (Production and Use) in the transportation sector. The savings are compared on the basis of the (1). per product impact (2). GhG emissions (3). air quality (4). use of water and (5). energy. MRE scored 90 % mark on unit impact with projections of scaled operations pushing replacement of 18% of the domestic road fuels utilization, thereby saving 17 billion metric tons of CO₂. MRE stations use 2.3 gallons of water to produce 1 kg of hydrogen (H₂). On average, 57 kWh is used to generate a kilogram of hydrogen with the calorific value of 33 kWh energy enough to power an LED bulb for 2 months. Recycling of the materials used on MRE equipment makes the innovation, even more eco-friendly. Furthermore, MRE been an innovation based on electrolysis, releases 7.9 kg of oxygen per kilogram instead of CO and CO₂ produced by other hydrogen production processes. This solution, promotes SDG 13, 6, 7, 12, and 3, hence environmental friendly.

PROFITABILITY

The **Profitability section** is aimed at determining the capacity of a Solution to deliver an economic incentive for the client, as well as to generate profits for the seller in a short term. This section is composed of two criteria and it considers: The capacity of a Solution to deliver an economic incentive (direct, indirect, or hidden economic savings) for the client (**Criterion 4**) compared to the mainstream alternative and the capacity of the Solution to generate profits for the seller (**Criterion 5**) in the short term, regardless of the marketing strategy and the novelty of the product.

EXPERTS REVIEWS

CRITERION 4 - CLIENT'S ECONOMIC INCENTIVE

Is the total cost of ownership of the Solution lower (or same) compared to the mainstream alternative? Please evaluate this considering potential hidden benefits for society, and foreseeable regulatory changes within 5 years.

YES

First Expert justification - MRE electrolysis is very competitive versus conventional hydrogen generation technologies. The levelized cost of hydrogen is higher than other more commonly used hydrogen production technologies. Compared with electrolysis, when subsidies are not considered, MRE hydrogen is superior when 100% wind supply is used. The cost of production is highly correlated to the electricity source. However, MRE and competing forms of electrolysis have similar environmental impacts (all impacts depend on grid energy source).

YES

Second Expert justification - The demonstration scale unit in the Innovator's Solution offer low cost entry to client's as they investigate the technology. The client may be less inclined to invest in the larger scale equipment until the Innovator establishes experience and demonstrates market viability to ensure reliable support over a 20+ year product life.

YES

Third Expert justification - Despite the Levelized Cost of Hydrogen (LCH₂) been higher than other sources of hydrogen production, when compared on non-subsidized basis, MRE hydrogen's hydrogen is superior when 100 % wind source is used. The price of one SHFA 200 MRE unit is \$150,000 with a discounted price on purchases of more than 25 units (\$97,500 each). The price per kg of hydrogen is \$16 and station owner can make a 2 % profit with an advantage of territorial exclusivity and expansion of more stations. Other sizes post profits of about 9%. The hydrogen market is approximated to be over \$2.5 Trillion by 2050, there by giving the investors or innovation users the chance to make profits.

CRITERION 5 - SELLER'S PROFITABILITY

Could the Solution itself be profitable for the seller within 5 years, with a sale's price at which clients would buy it? Please evaluate this regardless of the marketing strategy and the novelty of the product.

YES

First Expert justification - The Solution Provider has already indicated that its solution's commercialization stage has reached the breakeven point and is profitable. The solution provided profitable revenue in 2019 with \$ 1.2 million in sales. Purchase prices vary depending on the model but range from \$97.5K to \$1.35 Million.

YES

Second Expert justification - The Innovator has created a product line which scales with the market demand; demonstration scale to industrial scale. The Innovator could reach profitability within 5 years based on the demonstration scale units as there is strong demand and the technical solution is an appliance. It is less clear that the Innovator will reach profitability at industrial scale units as there is a gap in demonstrated technical experience at industrial scale.

YES

Third Expert justification - The innovator has indicated that 38 Hydrogen stations have been built in California and where subsidized 80 % by the state, pointing to the lack of sustainability of the financial model in building H2 fueling infrastructure. The stations should cost \$4 million to be profitable. Therefore MRE innovation with small, streamlined and modular designed stations aims at accelerating the deployment of hydrogen fueling infrastructure profitably and are scalable on demand. Breakeven point has already been met and the margins are, on SHFA 200 MODEL, \$21,450, SHFA 300 MODEL, \$46,750 and Mega 4 TA 70 Model at \$109,890 (22 % margins per unit sale. Therefore, the solution is profitable to the seller.

The information set out above, is solely for the purposes of information and the Solar Impulse Foundation does not provide any guarantee as to its authenticity, completeness or accuracy. This information is the direct outcome of the assessment performed by external non-remunerated experts that volunteered to review your solution submission form following the application of the Efficiency Assessment Process of the Solar Impulse Efficient Solution Label Standards. This information is shared to you as it might be of value for you to get the feedback provided on your application – regardless of the outcome of the general selection process.

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