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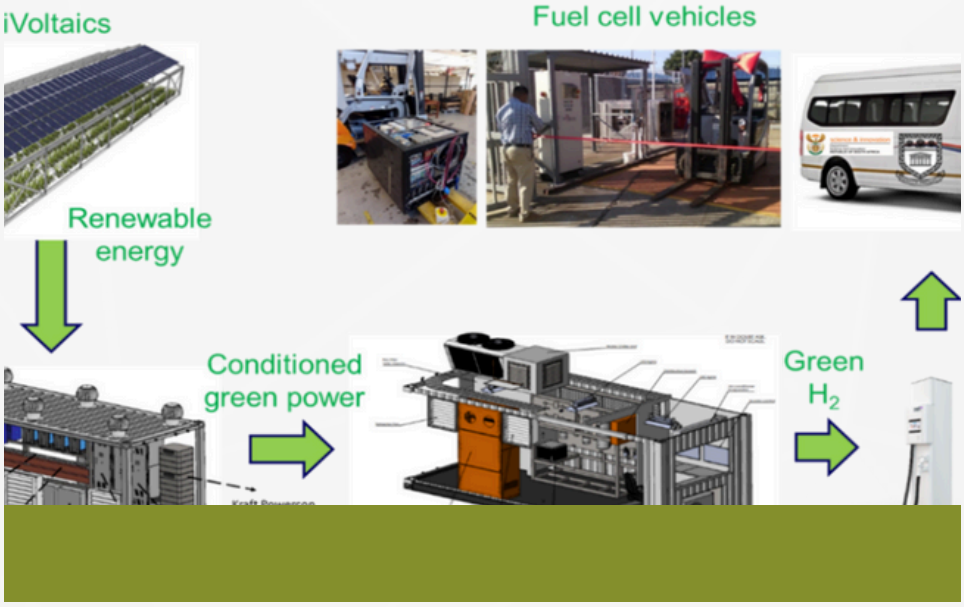
Green Hydrogen Transport Value Chain: Movable Sustainable Solution for Large Construction Sites, applicable for Taxi Ranks, Bus Terminals and Truck Depots, including Campuses and Airport Ground Transportation

Abstract:

Introduction: The Green Hydrogen Transport Value Chain (GHTVC) is a fully integrated, easy-to-move highly compact infrastructure system representing practical outcomes of HySA Systems/SAIAMC RDI activities in Hydrogen Economy. It generates and conditions renewable energy, produces, compresses, dispenses green H2 and supplies it to a small fleet of fuel cell operated vehicles, all on the basis of a locally built mobile platform that can be deployed within days or weeks anywhere in South Africa or wider African Continent. This project will leverage HySA Systems/SAIAMC manufactured prototypes, expertise, know-how and intellectual property accumulated through the past 20 years of dedicated efforts in the hydrogen, fuel cell and renewable energy domain, providing the much needed trust for industry early adopters in South Africa and beyond. GHTVC represents a robust South African response to the urgent need to accelerate renewable energy adoption locally, and not the least to forthcoming economic challenges associated with European Union's Carbon Border Adjustment Mechanism (CBAM). The components within the system are schematically presented in Figure 1 and briefly described below.



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1.90kW AgriPV System: Agrivoltaics harnesses solar energy, simultaneously providing the shade for crops and generating electricity. This innovative synergy increases agricultural productivity, reduces water usage, and promotes sustainable farming practices, forging a path towards greener future. Compact and potentially highly mobile hydroponics-based systems can form the cornerstone of South Africa's just energy transition, supplying nutritious food to previously disadvantaged communities and unlocks additional socioeconomic benefits of large infrastructure construction projects.

2.90kW Mobile Power Conditioning System

The electrical energy supplied by photovoltaic panels has become attractive value proposition, but requires conditioning and the presence of energy storage systems to generate high quality uninterrupted power. This component of GHTVC encompasses an integrated system of MPPTs, inverters, Li-ion batteries and a DC power module installed within a unique self-adjusting thermal management environment, providing stable 3 phase AC power for site needs and high current DC output specifically suitable for operating the Electrolyser System. Furthermore, the unique AC/DC bus design of the Power Conditioning System allows seamless integration with electrical charging stations for battery powered transportation, construction and utility vehicles.

3.50kW Mobile Electrolyser System

Among general solutions for reducing green hydrogen production costs, the use of small to medium scale independent hydrogen production stations is piloted worldwide. These stations not only eliminate transmission and loss costs but are becoming economically viable under high seasonal solar irradiation conditions and medium to low investment potential, prevailing in many parts of South Africa. The green hydrogen production Proton Exchange Membrane Water Electrolyser (PEMWE) system designed by SAIAMC is based on modular and versatile stacks originally sourced from the leading international supplier. This design is based on the mobile 10 kW PEMWE system manufactured by SAIAMC and successfully field-tested for 16 months. SAIAMC with its vast experience in electrolyser integration and demonstration, will build a 50kW electrolyser system based on the novel stack design, which will be locally assembled using the suite of recently procured world class stack manufacturing equipment., thereby localising the technology to reduce costs and facilitate commercialization.

4.H2 Refilling Station

HySA Systems has developed a single-stage prototype high-pressure Metal Hydride Hydrogen Compressor (MHHC) which is able to compress hydrogen from 100 to >500 bar at the working temperatures from 20 to 150 °C, with estimated productivity about 1 Nm3/h. Further advancing this breakthrough engineering solution will allow to integrate the compressor in the GHTVC movable infrastructure, providing mobile hydrogen refuelling station with a dispensing pressure of 350 bar and a refuelling capacity of 20 kg H2/day, which is sufficient to enable efficient operation of a small fleet of fuel cell vehicles.

1.Fuel Cell Vehicles

HySA Systems has manufactured several power module prototypes within the 1kW-20kW power range that are being leveraged to support the material handling platforms and utility vehicles, which operation is critically important for large construction sites. Moreover, the current development is focused on the 40 kW fuel cell power module, scalable to 80 and 120 kW, to be used in commercial buses, trucks, minibuses and wider utility fleet sectors aiming to support South Africa's hydrogen society roadmap (HSRM) targets and the planned hydrogen valley and mobility corridor initiatives. The 40kW power module then will be integrated into an electric minibus taxi that will be used to transport workers and passengers at a construction site or in the vicinity of a taxi rank. The vehicle will be refuelled with hydrogen from the 350bar refuelling station that will be installed at the site. In an alternative arrangement, a 3-tonne fuel cell forklift can be provided.

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System Summary:

A complete system containing AgriPV, Power Conditioning System, Electrolyser System, Hydrogen Refuelling Station and a fuel cell vehicle operating at a construction site, a taxi rank or a bus terminal offers numerous benefits, ranging from environmental sustainability and cost savings to technological innovation and community engagement. Implementation of such an innovative system at a construction site can stimulate job creation and economic growth within the community, including opportunities for local employment in construction, renewable energy and clean technology sectors, as well as potential business development and investment in the area.

The additional value of the system is within the independent functionality of each subsystem which creates the flexibility that is required for widespread technology adoption. For example; when a green hydrogen filling station is required in the middle of densely populated area, the AgriPV system can be replaced with a grid connection, wheeling green energy from remote RE generators, without any impact on the quality or quantity of dispensed hydrogen. Similarly, the power conditioning system provides the DC power needed for electrolysis but is equally ready to be deployed as part of a RE-EV charging station, a school, a clinic or any building in the immediate need of an uninterrupted green power supply. The electrolyser system produces the hydrogen for the filling station but this hydrogen can also be applied in industries other than the transport sector. Finally, the FC operated vehicle represents a universal downstream user platform for industry and society decarbonisation.

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