Review: Uninterrupted Liquid Hydrogen (E-Methanol) Production framework to deliver Clean & Green Energy

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Abstract

Potential broad impact: Integrating solar, wind, and conventional energy to feed the electrolyze after completion of the electrical process will produce two streams of O2 and H2. The hydrogen stream will be stored and provided with uninterrupted feed to a catalytic reactor in the presence of CO2. It will produce E-Methanol[1]. However, this depends on these resources' reliability, cost, and availability, with the highest potential for expansion to the size needed for large-scale deployment to produce e-methanol[2]. This is known as electro-fuel, which provides electricity and fuel for electric and diesel vehicles[3][4].

As witnessed the versatility of Hydrogen in these applications highlights its significance in various industrial sectors. As the world looks towards sustainable and clean energy solutions, the role of Hydrogen is expected to grow even further [5]. However, the central part of Hydrogen is produced from fossil fuels (known as gray and brown Hydrogen) [6], and only a minimal amount of almost 4% is delivered through an electrolysis process using renewable energy to complete the chemical process [7], known as green Hydrogen.

Introduction

Green Hydrogen refers to Hydrogen produced using renewable energy sources and a process called electrolysis. Advancements in the efficiency and durability of electrolysis technologies are crucial for making green hydrogen production economically viable and competitive with other forms of hydrogen production[14]. Pure Hydrogen is a versatile and vital resource in various industrial processes. It serves as a critical feedstock and energy carrier, playing a crucial role in different sectors such as ammonia production, petroleum refining, methanol production [15], hydrogenation processes, electronics and semiconductor manufacturing, power generation, hydrogen fuel cells in transportation[16], etc.

Figure No.1. whereas the pure hydrogen is playing vital role in petrochemical industries in the large spectrum[17]. Essentially the Hydrogen catalyzing diverse range of petrochemical industries, including the chemical (for methanol, ammonia, and polymers), refining (for hydrocracking and hydrotreating), metal processing [18], aerospace, glass, and food industries. Interest in green hydrogen as a renewable fuel is also growing. Hydrogen is still produced from fossil fuels (brown and grey hydrogen)[19]. This also produced high intensity of carbon footprints which is non-renewable. Whereas 48% produced from natural gas, 30% from light/heavy oil and 18% from coal respectively[20].

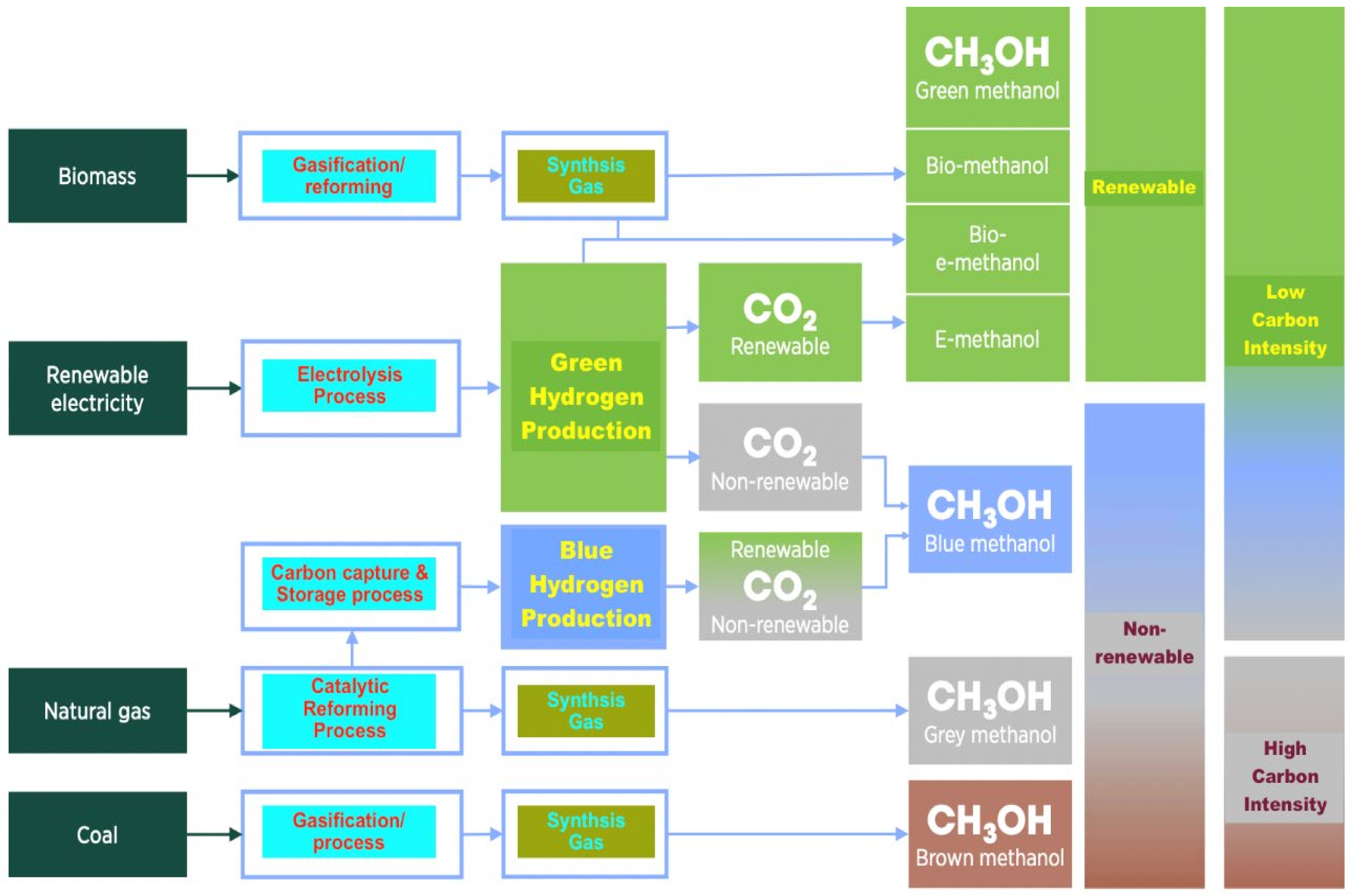

Fig.1 Different types of hydrogen production process

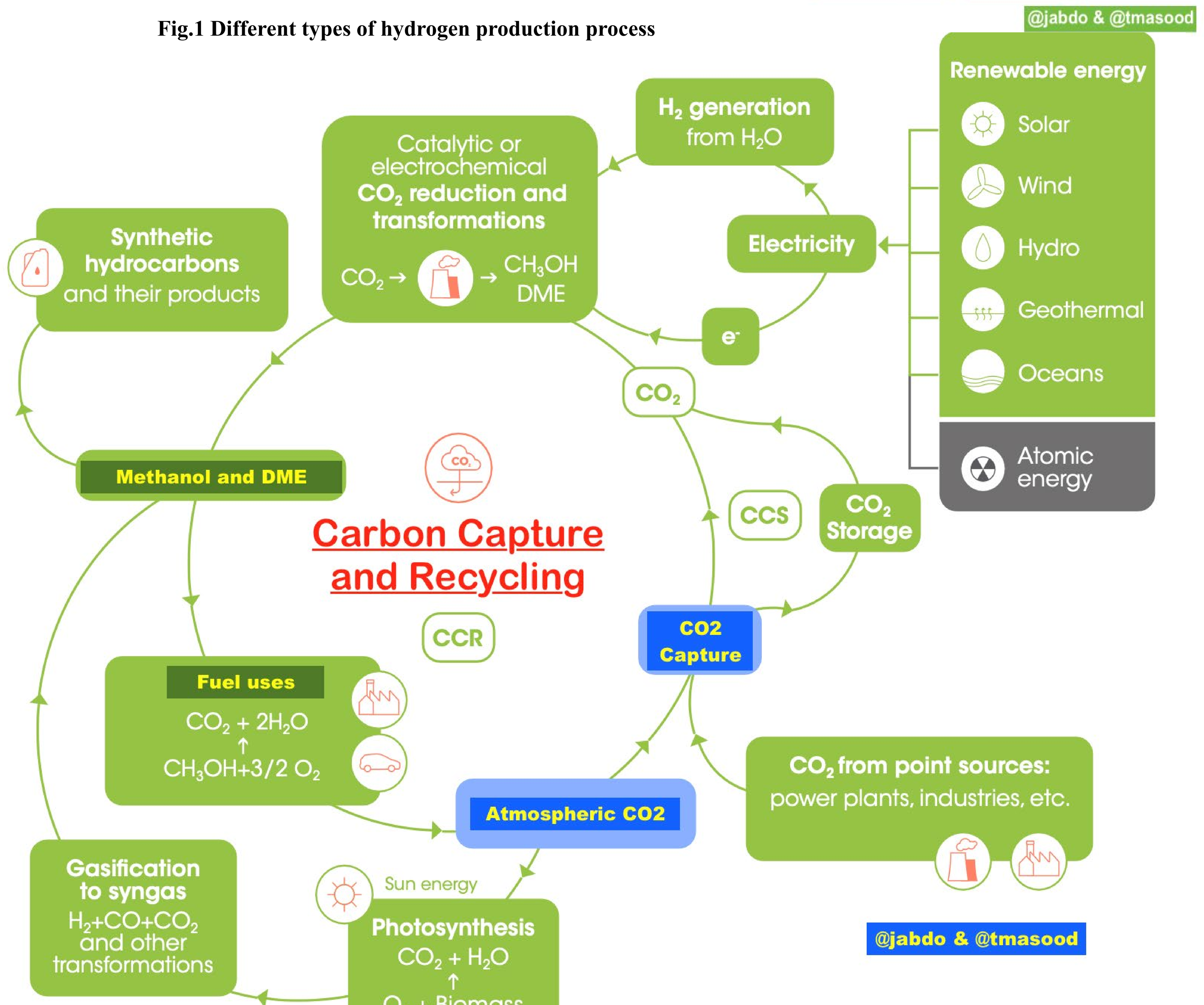

Fig.2 Anthropogenetic carbon cycle for a circular economy

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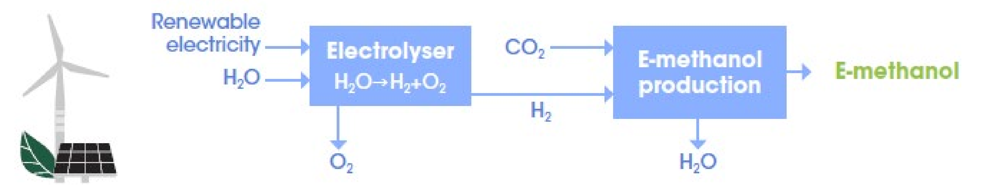

Fig.3 Electrolysis of water to hydrogen

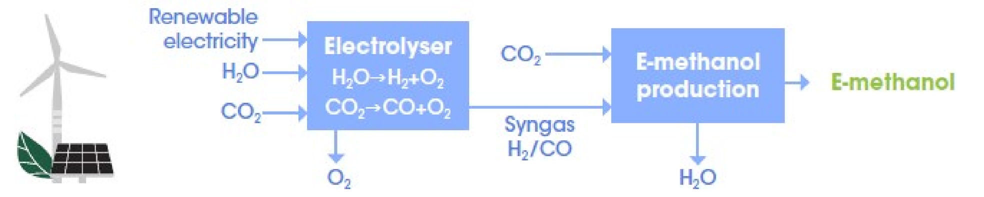

Fig.4 electrolysis of water & Carbon dioxide

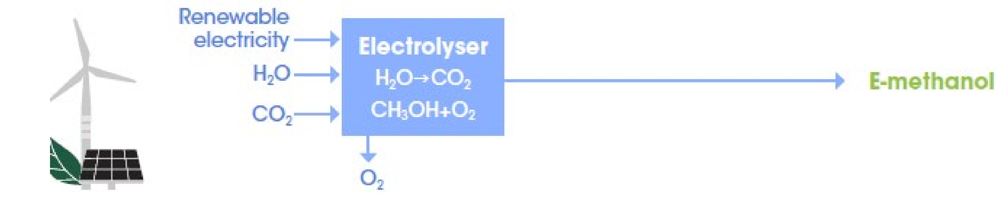

Fig.5 Direct electrocatalytic H2O & CO_2

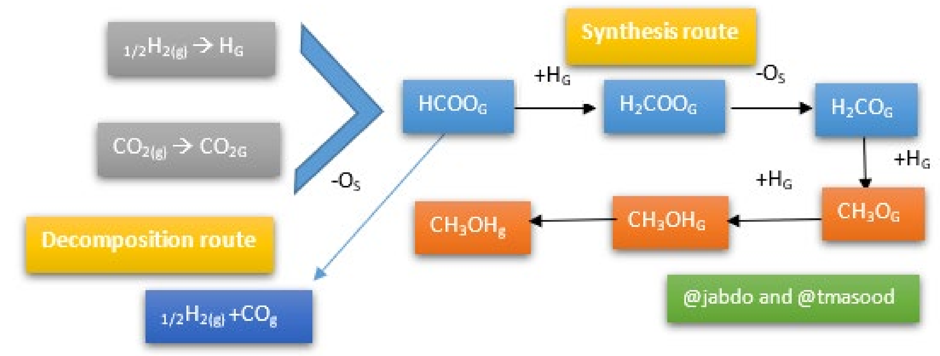

Fig.6 Chemisorption & industrial catalytic process

Critical Aspects Green & Clean Energy

Renewable Energy Integration Modular with port equipment: Examine how solar and wind energy sources can be effectively integrated into the electrolysis process also known Chemisorption as shown Fig.5 and its port equipment(s) (1) Electorylzer, (2) Separator of Liquid and gas, (3) Compressor, (4) Boiler, (5) Catalytic Reactor, (6) Reducing valve, (7) Absorber, (8) Stripper and (9) Distillation column Renewable and Conventional Power Utilities. Consider the variability of these renewable sources and explore methods to ensure a consistent and reliable energy supply for the electrolyzer.

Hybrid Renewable Systems: Investigate the benefits of creating a hybrid renewable energy system that combines solar and wind technologies. This can enhance the overall efficiency and reliability of the system, especially in locations with variable weather conditions.

Fig.2 Anthropogenetic carbon cycle for a circular economy

Electrolyzer Technology: Explore different types of electrolyzers, such as alkaline electrolyzers, proton exchange membrane (PEM) electrolyzers, and solid oxide electrolyzers. Evaluate their efficiencies, durability, and suitability for integration with renewable energy sources.

Voltage Control Model

In the linear operating control model's Buck and Boost Converters designed to control the voltage, the AC system terminal internal voltage V and reference voltage V_{Ref} as given in the equation 3 and its parameters are also defined .

$$V_T = V\frac{1}{1+G_1G_2HX} + V_{Ref}\frac{G_1G_2X}{1+G_1G_2HX}$$

In the second form of operation's control model has been developed to produce the results as per defined as mathematical model. The control transfer functions which have been verified to maintain it operational credibility which has been formulated in control as given below . The concept is to develop and customize the Smart control Devices to optimize its operating parameters by incorporating new control compensation control parameters. In this method, the control system has three operating and control boundaries in order to run the system successful to achieve the following.

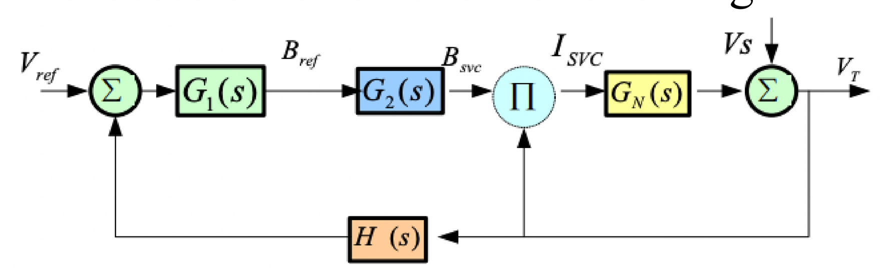

Fig. 7 Power delivery control model

- Increased Power Transfer capability
- Improved reliability
- Improved controllability
- Enhanced angle and voltage stability

Conclusion/ Discussion

Introducing clean and green energy initiatives is essential to crafting the right policies and incentives, which is crucial to meeting the goals of carbon emission reduction, energy security, sustainability, and improvement in quality of life in the world by large. Green Energy initiatives would only happen with confidence in strong, stable, predictable, and sustained government policy. In the transport sector, especially for passenger cars, policy must focus on electromobility and support for increasing the share of EVs. Meanwhile, Green Hydrogen fuel cells and batteries are strong candidates to serve the purpose, essentially inroads, and charging infrastructure needs to expand.