

It is Time to Realize the Potential of Turquoise Hydrogen

Abstract

Hydrogen is attracting growing interest from a variety of sectors and stakeholders as a potentially valuable decarbonization tool. The majority hydrogen produced today is used for oil refining and ammonia production, but proponents argue its applications can be expanded to wider industrial uses, transportation, buildings, and even power generation. To a considerable extent, the viability of hydrogen in these sectors, as well as how extensive that role might be, depends overwhelmingly on its green credentials and its cost competitiveness. It is time to realize the potential of turquoise hydrogen.

Hydrogen can be produced in several ways, both with fossil fuels and with renewable energy, however, decarbonized hydrogen is currently not cost-competitive with hydrogen derived from fossil fuels. This raises questions about how best to bridge that gap for the decarbonization of existing hydrogen demand, as well as for other potential applications. Turquoise hydrogen is a type of carbon neutral hydrogen produced from natural gas through a process known as pyrolysis, or a process that decomposes using high temperatures. Natural gas is cooked at approximately 500 °C until it breaks down into solid carbon and hydrogen. That hydrogen is then used for everything from home heating to power generation, to industrial processes, to ammonium fertilizer production. But what happens to the carbon, which is an offset to make Turquoise Hydrogen cost efficient?

The carbon, also called synthetic graphite or carbon black, is a solid material and therefore does not contribute to greenhouse gas emissions and does not need to be injected into underground storage which is the case with CO₂. This solid carbon has a variety of industrial applications. It's used in products including but not limited to printer ink, tires, steel production, hydrogen fuel cells and fabrication of devices like batteries and solar panels.

From an economical perspective, production of turquoise hydrogen indirectly makes it cheaper to produce other products and even types of renewable energy while directly providing reliable, affordable, and dispatchable zero-carbon energy. Another benefit it potentially provides, is a lower carbon footprint for solar panel production, as the synthetic graphite

currently used for this process is largely produced via heat treatment of petroleum coke, coal-tar pitch, or oil.

Turquoise hydrogen not only represents an affordable energy solution but emerges as an exceptionally cost-effective choice in the realm of hydrogen production. Let's delve into the compelling economics that make turquoise hydrogen a true financial asset.

At the heart of this groundbreaking solution is natural gas. This, coupled with innovative production methods, positions turquoise hydrogen as one of the lowest energy costs among developed nations. According to the Energy Information Administration (EIA), natural gas is projected to maintain a cost advantage, ranging between half and a third of other energy sources, up to the year 2050. Consequently, the feedstock costs for turquoise hydrogen will remain remarkably low.

Astonishingly, when factoring in natural gas and pyrolysis costs, the production cost of turquoise hydrogen can be one that provides hydrogen production a sustainable future. Much faster than green hydrogen ever can.

Moreover, the intrinsic value of hydrogen, coupled with the market demand for the synthetic graphite byproduct, which commands a selling price of approximately \$1,000 per metric ton, adds another layer of profitability to the equation. The financial incentive to expedite turquoise hydrogen production is undeniably compelling.

In conclusion, the confluence of abundant natural gas reserves, innovative production methods, and

marketable byproducts positions turquoise hydrogen as an economically sound and highly profitable venture. The economic viability of this energy solution speaks for itself, making it an attractive proposition for those looking to invest in a sustainable and financially rewarding future.

So, why is turquoise hydrogen not high on the sustainable agenda? Turquoise hydrogen still lacks the name recognition of blue hydrogen, which is produced with natural gas using carbon capture technology, or green hydrogen, produced using renewable-powered electricity.

Despite this, we believe more people should be betting on methane pyrolysis to reach the climate change goals and objectives and reduce the price of clean hydrogen to less than \$1 per kilogram.

We frankly think turquoise hydrogen has a much better chance to realize these objectives than blue or green hydrogen production methods, both in economic and technical sense. Turquoise hydrogen is also a relative new entry in the hydrogen color charts and production has yet to be proven at scale.

Natural gas utilities have mastered the art of transporting hydrogen, currently utilizing a fuel mix that comprises approximately 50 percent hydrogen. The breakthrough technology of pyrolysis offers a game-changing advantage – turquoise hydrogen can be produced on-site for large industrial customers using existing natural gas networks, sidestepping potential hurdles to widespread hydrogen adoption.

The potential for decarbonizing heavy industry is staggering. Traditionally reliant on coal, recent innovations allow hydrogen to replace coal in approximately 70 percent of global steel manufacturing. On-site production of hydrogen and synthetic graphite within heavy industry facilities presents a transformative opportunity for substantial emissions reduction, exclusively for facilities linked to the natural gas distribution system.

In the realm of home energy use, high-efficiency natural gas homes outperform their counterparts. Turquoise, blue, and green hydrogen, blended into the energy mix, along with innovative gas heat pumps, offer the promise of further emissions reduction, specifically for homes connected to the natural gas distribution system.

Power generation, a high emission contributor in our society, is a key area where turquoise hydrogen could wield significant influence. Retrofitting existing power plants for hydrogen combustion or blends swiftly lowers emissions, provided the power plants are connected to the natural gas distribution system.

Transportation, contributing substantial to our emissions, also stands to benefit from turquoise hydrogen. Hydrogen fuel cell buses, hydrogen as an alternative aviation fuel, and car manufacturers investing in commercializing hydrogen fuel cells for cars showcase the potential for mitigating bottlenecks in power production and charging infrastructure rollout. However, a prerequisite for success is being connected to a natural gas distribution system.

Across various sectors, turquoise hydrogen emerges as a considerable and powerful tool for emission reduction. The allure of this innovation is further heightened by its relative low production cost, which could potentially lead to lower energy prices for consumers.

The ongoing energy transition is unprecedented due to its scale and the profound impact on the established socio-economic, technological, and geopolitical trends around the world. Renewables, in combination with energy efficiency, now form the leading edge of a far-reaching global energy transition.

Turquoise hydrogen has great economic potential and deserves substantial research attention toward scale-up of enabling technologies. It offers an attractive low-carbon hydrogen solution to regions without any CO₂ storage potential and can economically supply growing markets for high-purity carbon.

Such high-value markets also offer a clear path to technological maturity by ensuring the profitability of investments in expensive first-of-a-kind plants. Besides, developing hydrogen from methane pyrolysis, aligning future industries for the use of black Carbon is a business on its own.

Anticipated to soar at an impressive Compound Annual Growth Rate (CAGR) of 160% between 2024 and 2032, we believe the turquoise hydrogen market stands at the brink of a transformative growth, set to reshape the industrial landscape. At the heart of this surge lies a collective global commitment to curbing greenhouse

gas emissions, propelling turquoise hydrogen into the spotlight as a pivotal solution.

Distinguished by its ability to yield hydrogen with substantially reduced carbon footprints compared to conventional methods, turquoise hydrogen emerges as a beacon for decarbonization across critical sectors like transportation, industrial processes, and power generation. Governments, corporations, and industry stakeholders alike are acknowledging the pivotal role of turquoise hydrogen in realizing Article adoption.

Moreover, the burgeoning demand for the integration of renewable energy sources underscores the burgeoning turquoise hydrogen market. Harnessing renewable energy reservoirs such as wind or solar power, turquoise hydrogen assumes the role of a fundamental facilitator in the storage and utilization of renewable energy, amplifying its significance in the transition towards sustainable energy practices. It's about time that we recognize turquoise hydrogen as a game changer in the transformation of our energy sector and provide it the attention and recognition it deserves.

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