Hydrogen,
the future of energy

GAZPACK

We clean bio gaz and oil gaz

Introduction

Fossil fuels gave an enormous boost to the progress of the Industrial Revolution and beyond. At the same time, the discoveries of recent decades reveal that these advances were not without their side effects, namely the atmospheric deterioration attendant upon carbon dioxide (CO2) emissions. In response to this reality, researchers are focusing on the development of renewable sources of energy to compete with and reduce those obtained from the earth's crust. In a larger context, scientists and policy makers seek to establish sustainable development goals (SDGs) that not only diminish carbon in the atmosphere, but utilize all natural resources in a manner that assures their continual flourishing.

This paper will focus on the use and modification of natural gas as an environmentally friendly fuel medium. With some of the United Nations SDGs in mind -- e.g. affordable and clean energy, responsible consumption and production and climate action -- this work will attempt to discern how steam methane reforming (SMR) might fit into the SDG framework. In addition, discussion will ensue as to what the alternatives to SMR are. Concluding the presentation is the role the Dutch firm Gazpack plays in SMR and renewable energy development.

Backstopping the information presented below are references from government agencies like the U.S. Department of Energy and the National Renewable Energy Library; global organizations such as the International Energy Agency (IEA); private energy companies, Shell plc, for example; and scientific research companies like TNO, also based in the Netherlands. Drawing from diverse perspectives allows for a robust discussion of scientific facts and their practical applications. Moreover, it can demonstrate any consensus that emerges as to SMR steam methane reforming, its applications and its standing among other advances in energy conservation and transformation. The aim is to determine whether SMR should invite more research and investment.

Chapter

01 Growing Importance of Reducing Greenhouse Gas Emissions in the Oil and Gas Industry

SMR is one component of a larger effort to eventually rid the atmosphere of harmful greenhouse gases. A large body of scientific research demonstrates that high levels of these gases retain heat in the earth's atmosphere, resulting in a number of environmental ailments. Among these are a climbing surface temperature; shrinking snow pack in the mountains; ascending sea levels; more frequent droughts; and subsequent increase in wildfires. These are just a few reasons why there is a growing urgency to reverse the warming trend.

The battle is fought on multiple fronts but addressing the combustion of fossil fuels is a primary campaign since this activity produces the vast amount of excess CO2 -- 78 percent since 1970 according to the U.S. Environmental Protection Agency. The largest contributing combustible materials are oil, coal and -- to a lesser degree -- natural gas. Much time, money and intellect is currently applied to the problem of replacing these incendiary substances with other means of generating electricity. Target dates are set, and sometimes re-set, for zero net carbon emissions by governments, industries and environmental organizations.

Chapter 02

Transition of Natural Gas into Hydrogen -- A Solution to Reducing Greenhouse Gas Emissions in the Oil and Gas Industry

Of all fossil fuels, natural gas emits the least CH4 when combusted. The U.S. Energy Information Administration reports that the pounds of CO2 released by burning natural gas amounts to nearly half of that put out by coal and three-quarters of the quantity in the case of fuel oil. It is little surprise, then, that -- in anticipation of alternative energy widespread availability -- natural gas ranks as the preferred fuel source. Still, bearing the SDG aims in mind, natural gas users need not simply accept the status quo of burning the gas for electricity.

While its detrimental effects are less than those of oil and coal, natural gas nevertheless generates significant greenhouse emissions in the form of methane that leaks out from abandoned wells as well as vessels for transport and storage. In addition, the exploration and drilling attendant to natural gas production is known to disturb adjacent vegetation and wildlife -- in direct contradiction of SDG values. Thus, the old way of doing business relative to natural gas is ripe for retirement, giving rise to new approaches to this dynamic yet risky resource.

Under routine circumstances, natural gas leads to electricity in the same manner as its fossil fuel peers: the heat of combustion creates steam that moves a turbine to make electricity. Efficiency suffers in this process since only about 34 percent of the thermal energy released from combustion provides steam that actually makes it to the electrical generator. Other electrical utilities improve on this by replacing steam units with those that turn the turbines by means of the hot gases that come from combusted natural gas. Still other producers engage a hybrid of steam and hot gas. Yet better efficiency does not always mean realization of SDG objectives.

Enter hydrogen.

First on the Periodic Table, hydrogen (H) is the most ubiquitous element in the known universe. Without taste, odor or appearance, hydrogen gas (H2) is also highly flammable and -- under intense pressure -- nearly three times the energy density of natural gas. Why is this fairly obvious information important? While not an energy source that can be drawn from geological deposits, hydrogen has the capacity to transport and even store immense amounts of energy, making the gas a valuable actor in the transformation of natural gas into electricity -- and doing so efficiently.

Hydrogen is extracted from natural gas through the process of steam methane reformation. In the SMR process, the CH_4 in natural gas reacts with steam under a pressure of approximately 47 to 48 pounds per square inch (psi). With a catalyst present, the steam methane reforming process releases hydrogen, carbon monoxide (CO) and CO_2. This endothermic sequence then yields a "water-gas shift reaction," whereby additional H_2 and CO_2 (syngas) is created. In the final event after the steam methane reforming reaction, the CO_2 and other compounds are cleansed from the steam -- pressure swing adsorption -- to leave a refined H_2 gas in their wake.

A steam methane reforming process flow diagram would look something like this:

$CH_4 + H_2O$ (+ heat) $\rightarrow CO + 3H_2$ followed by $CO + H_2O \rightarrow CO_2 + H_2$ (+ small amount of heat)

Another way of retrieving H from natural gas is partial oxidation. Obtained often from air, the oxygen that reacts with the CH_4 is limited so not to fully oxidize the hydrocarbons, leaving only CO_2 and H_2O. Instead, partial oxidation releases H_2, CO, nitrogen (N) and a modest amount of CO_2. In the next phase, the CO and H_2O react to produce more H and CO_2.

The CO_2 that is still present after hydrogen production, can be separated by means of liquification, after which it would be feasible to inject it back into the earth. Since it is a natural product there is no harm in doing so. Most efficient way where to inject the CO_2, would be where it is found, since this normally would be closest by, and therefore the most cost effective way. An even more cost effective method, if possible, would be to use the CO_2 in semi-exhausted wells to lift the remaining gas.

Chapter

03 Other Alternatives to Fossil Fuels

Wind power is a popular and promising alternative -- large turbines now dot rural landscapes and appear at many offshore locales. This option is free, clean and relatively non-disruptive. However, it demands more mining of metals, can kill avian species during migration and generate unwelcome noise. Solar power, likewise, emits no carbon, is relatively inexpensive over time and has myriad applications. Then again, it demands a great deal of space and, like wind turbines, relies on materials that are not easily obtained. Advocates are hopeful further research can ameliorate some of these challenges. At any rate, the consensus remains that burning fossil fuels at the current rate should not continue.

Wind and solar are the most celebrated earth-friendly substitutes for fossil fuels yet there are other options worthy of pursuit, as well. One such choice is biogas, i.e. natural gas derived from organic material as opposed to geological deposits. This source comes from a variety of substrates: livestock manure, wildlife droppings, composted food scraps, fallen foliage, dead grass, wastewater, sewage, landfill contents and a host of other decaying matter. Through the process of anaerobic digestion, methane (CH4) is extracted from the substrate, refined and used for vehicle fuel and electricity generation.

Biomass is another way to minimize the combustion of petroleum and coal. Biomass differs from biogas in that the organic material itself is burned for energy rather than the derivative CH4. Biomass combusts in a boiling apparatus and this ignition generates high-pressure steam. The steam, in turn, activates turbine blade movement, triggering electricity generation. The feedstocks for biomass energy are similar to substrate for biogas production. Meanwhile, hydropower harnesses the energy of moving water to supply mechanical energy for electricity generation. Geothermal energy is utilized for heating buildings and creating electrical power.

Chapter 04

Transitioning Natural Gas into Hydrogen vs. Transitioning Natural Gas into Electricity

Natural gas reactions that yield hydrogen might be more efficient ways to generate electricity in the long run. This is because of the work H2 does in fuel cells. These battery-like components in electricity generation maintain life as long as the fuel keeps flowing. They each consist of positive and negative electrodes that flank an electrolyte. The negative electrode receives the hydrogen while the positive electrode takes in air. At the negative pole, a catalyst divides the protons and electrons in the hydrogen molecules: the protons take a direct route to the positive electrode, going through the electrolyte, while the electrons bypass the electrolyte, generating electricity as they go. Upon arriving at the positive electrode, the protons give off water and heat.

Certain things are evident from these chemical transactions relative to the steam reforming process and hydrogen fuel cells. For one thing, the steam methane reforming CO2 emissions appear to be less than those when producers burn natural gas to create electricity. Another benefit is that more than two-thirds of the H2 captured for fuel cells is used by them, contrasting with the 66 percent of thermal energy lost in more traditional use of natural gas feedstock. UN SDG sustainability principles are also furthered by steam reforming of natural gas.

Natural gas is the “greenest” of fossil fuels and it is also the cheapest. Recognizing its inefficiency as a combustion agent, its use as a reactant in the creation of hydrogen makes it much more cost-effective. Steam reforming, then, represents an advance in electricity generation over the ignition of natural gas from the earth’s crust and, for that matter, organically derived natural gas, i.e. biogas. Although biogas is responsible for zero net carbon emissions -- because its substrate is already emitting greenhouse gas in decomposition -- it nevertheless generates modest heat just as its geological counterpart does. For electricity output, obtaining hydrogen from a steam reforming reaction also ranks above burning the CH4 from anaerobic digestion.

Chapter

05 Conclusion/Solution

Cleaner, greener, more efficient and, therefore, less expensive, steam reforming hydrogen is an attractive solution to the problems of natural gas carbon emissions and productive inefficiency. In hydrogen fuel cells, chemical energy converts to electricity straightaway, as the steam methane reforming process description demonstrates. In this way, more heat leads to more electrical current. The hope is, of course that, if the process is executed correctly, less natural gas is needed for more electric power.

Hydrogen fuel cells are not without challenges. Research is ongoing on how to lower the high cost of platinum required for the hydrogen fuel cells. Scientists are investigating the prospect of using less platinum and platinum alloys without reducing fuel cell performance. Developing better membrane electrode assemblies with stronger density; changing the designs so the cells can operate under a wider spectrum of conditions; and engineering new stacks where the efficiency corresponds to fuel cell effectiveness are all primary scientific objectives.

Those questions acknowledged, the Department of Energy is looking to bring system durability up to 80,000 hours at power plants that employ hydrogen fuel cells. This technological stamina must account for starting and stopping generation; temperature extremes; humidity; and the demand cycles, all of which burden mechanical and chemical stability. If successful, researchers can put forward designs and materials that reduce the vulnerability and fatigue of hydrogen fuel cell electricity production. With government and businesses partnering in these efforts, there appears to be a consensus that hydrogen steam methane reformation is the more promising power generating approach for the near future.

Deserving equal emphasis as power plant application is the use of hydrogen fuel cells in electric vehicles (EVs). Most EVs are passenger cars and buses, though trucks and tractors are also in use. Completely propelled by electricity, these conveyances emit only water vapor from their tailpipes. Hydrogen fuel cell electric vehicles retain their energy in fuel cells as opposed to batteries. Many of the rare earth elements required by batteries are spared as a result.

Chapter

06 About Gazpack

Gazpack is a Dutch firm that specializes in removing impure compounds and elements from organically derived and earth-based fuels. In its nearly 17 years of operation, Gazpack has manufactured various systems that clean both oil gas and biogas. One of its most celebrated systems fully removes sulfur from biogas (less than 1 ppmV), rendering the latter into multiple practical applications without any unproductive remainder. Discerning the molecular similarity between oil gas and biogas, Gazpack's founders found ways to make use of the contaminants, thus diminishing the need for flaring. This conversion of what was once considered waste not only led to new and useful products, it also counters the pollution attendant to flaring.

The patented SULAWAY system purifies high-volume biogas into cleaner burning biomethane, removing copious amounts of hydrogen sulfide (H2S) from the biogas. In so doing, it puts gas supplies in compliance with the Paris climate accords by delivering biomethane that is nearly 100 percent free of contaminants. Better still, SULAWAY effectively captures CO2 in a way in which the gas can be stored and sold, to the food and beverage segment for example. Meanwhile, the apprehended H2S is then available for fermentation processes and battery production. SULAGO is a Gazpack unit that operates on similar principles except that its design accommodates smaller capacities of biogas.

These Gazpack cleaning systems help energy users and producers comply with many of the UN's 17 sustainability goals: good health and well-being; affordable and clean energy; industry innovation and infrastructure; sustainable cities and communities; climate action; responsible production and consumption; and life on land are all advanced by Gazpack technology that eliminates chemical waste. Outside of these contributions, the cleansing of biogas and oil are expensive and time-consuming. Gazpack takes already sustainable practices like biogas production and makes them greener and economically optimal.

From ancient and indigenous practices to state-of-the-art, 21st-century technology, efficient use of resources proves to be key in sustainable cultures, biomes and even businesses. As demonstrated above, making full use of materials once discarded can produce numerous streams of revenue. Furthermore, it protects industrial workers and the general public when toxic waste products are re-purposed and utilized safely. Above all, it is a "win-win" scenario when neither land, sea nor air are polluted and economic productivity continues unabated. Gazpack is founded and lead based on such positive outcomes. This is why Gazpack represents the future of energy production.

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