The SPECTRUM of a Hydrogen Economy

In the quest for decarbonization, transitioning to a hydrogen-based economy could offer a realistic path to net zero emissions across the energy marketplace. Net zero refers to the balance between the amount of greenhouse gas produced and the amount removed from the atmosphere. Southwest Research Institute is investigating a palette of hydrogen technologies to develop clean, affordable and reliable energy, reducing our dependence on fossil fuels and looking for greener alternatives.

When the oil and gas industry refers to the hues of hydrogen, it refers to the different processes used to produce each. While hydrogen is an invisible gas, color codes – green, blue, turquoise and grey hydrogen – highlight the environmental footprint associated with hydrogen production.

In addition to power production, SwRI is investigating using hydrogen in transportation activities including fuel cells in medium- and heavy-duty applications and as fuel for internal combustion engines. These applications could reduce carbon emissions, but the actual carbon footprint would largely be determined by the source or "color" of the hydrogen.

Other challenges to the hydrogen economy include hydrogen transport and safety. For example, hydrogen embrittlement could compromise existing natural gas pipeline infrastructure, and the low density of hydrogen gas makes it harder to pressurize and push around the pipeline network. Plus, small-size hydrogen molecules could increase leak risks and are flammable over a range of concentrations. Pressurized vessels containing compressed hydrogen are also subject to rupture if the vessel is compromised. SwRI is conducting research to characterize and mitigate these risks.

	GREY HYDROGEN	BLUE HYDROGEN	TURQUOISE HYDROGEN	GREEN HYDROGEN
Process	SMR or gasification	SMR or gasification with carbon capture (85-95%)	Pyrolysis	Electrolysis
Source	Methane or coal	Methane or coal	Methane	Renewable electricity
	Grey hydrogen (H_2), the most common form of H_2, is created using steam methane reformation (SMR) without sequestering the greenhouse gases made in the process. SMR, which emits 7 kg of carbon dioxide (CO_2) for every kg of H_2 produced, is only low carbon if CO_2 is captured and stored permanently.	Blue hydrogen is a low-carbon resource, also produced using steam reforming. The process uses natural gas to produce H_2 and CO_2, but the CO_2 is captured and stored. SwRI is investigating new carbon capture and storage techniques to decarbonize the process.	Turquoise hydrogen is an emerging resource, produced using methane pyrolysis without gaseous carbon emissions. The thermal process splits methane, producing H_2 and carbon solids. SwRI is researching unique reactor designs and process conditions to reduce the energy penalty and carbon emissions associated with the process and improve the utility of carbon solid byproducts.	Green H_2 is a zero-carbon resource, produced using electrolysis powered by surplus renewable energy from solar and wind resources. SwRI is studying the electrochemical reaction used to split water into hydrogen and oxygen, emitting no CO_2 in the process. Chemical engineers are researching ways to lower the cost of electrolyzer construction and improve current efficiencies.