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Integration of Produced Water Thermal Desalination and Steam Methane Reforming for Efficient Hydrogen Production

University of Wyoming Hydrogen Energy Research Center
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Introduction

Wyoming contains large amounts of carbon-intense energy resources that are often located near hydrocarbon well fields. These fields produce methane and a saline brine (produced water). Being a dry and arid state with limited water resources, there is a need to convert this produced water into a more useable substance. Through supercritical water desalination and oxidation (SCWDO), this water can be improved to a useable product that can benefit other industries.

Hydrogen has great potential for energy storage and transportation to assist in the clean energy transition. DOE has released goals of producing hydrogen for $1/kg by 2036[1]. One of the most common ways to produce hydrogen is through the process of steam methane reforming (SMR) which can be combined with carbon capture to create low-carbon or "blue" hydrogen. This resource can then be used to benefit Wyoming in industries such as the Trona and Phosphate industries, in addition to the exportation of hydrogen energy and hydrogen bearing chemicals such as methane and ammonia.

Objectives

The goal of this project is to design, build, demonstrate, and field-test a semi-mobile integrated supercritical water desalination and oxidation (SCWDO) and SMR unit[2]. This system is shown as assembled in Figure 1 and the process involved is circled in green in Figure 2. The combination of these processes aims to field demonstrate a 15% cost reduction in the hydrogen production over current SMR technologies while producing hydrogen at a rate of 1 ton per day.

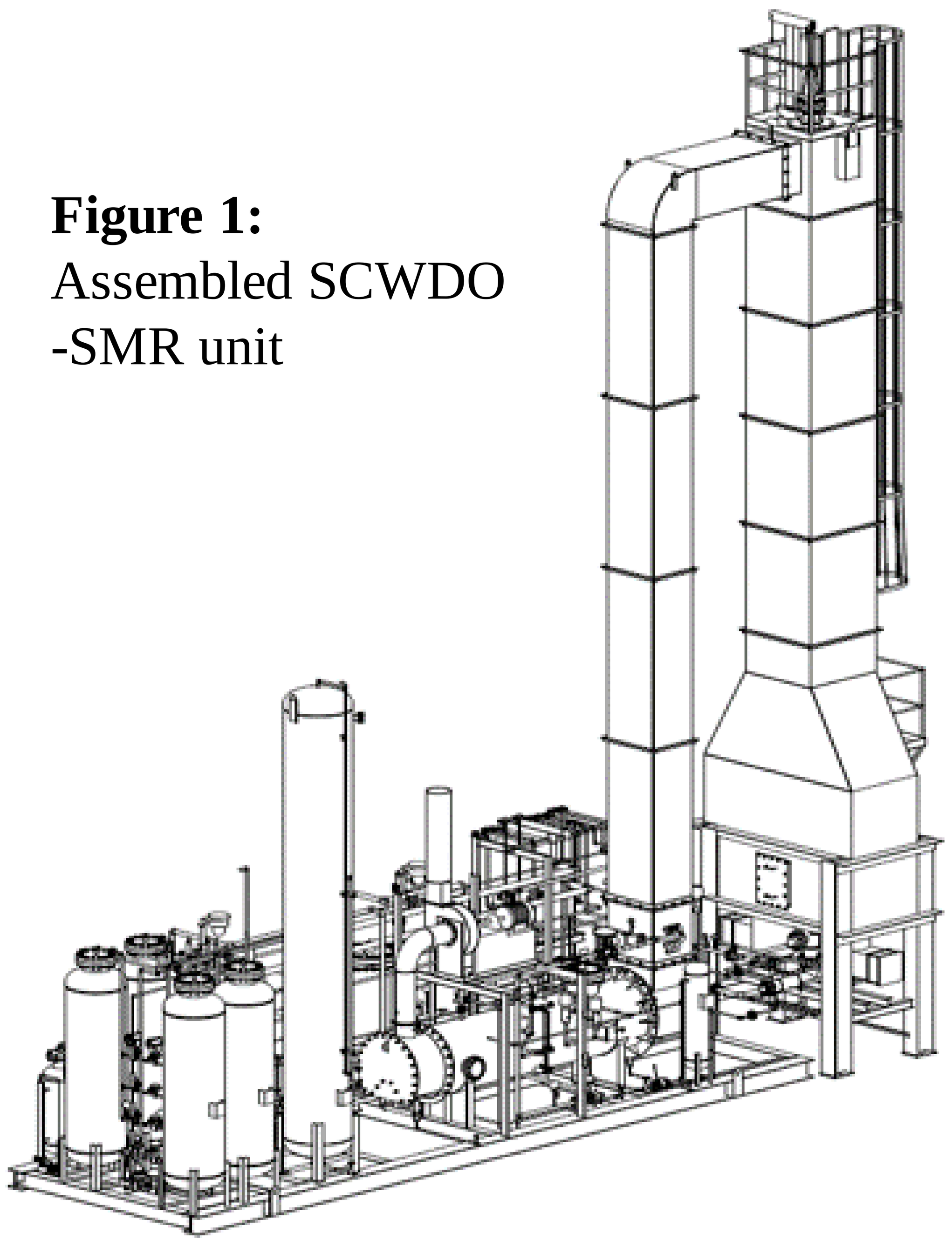

Figure 1: Assembled SCWDO -SMR unit

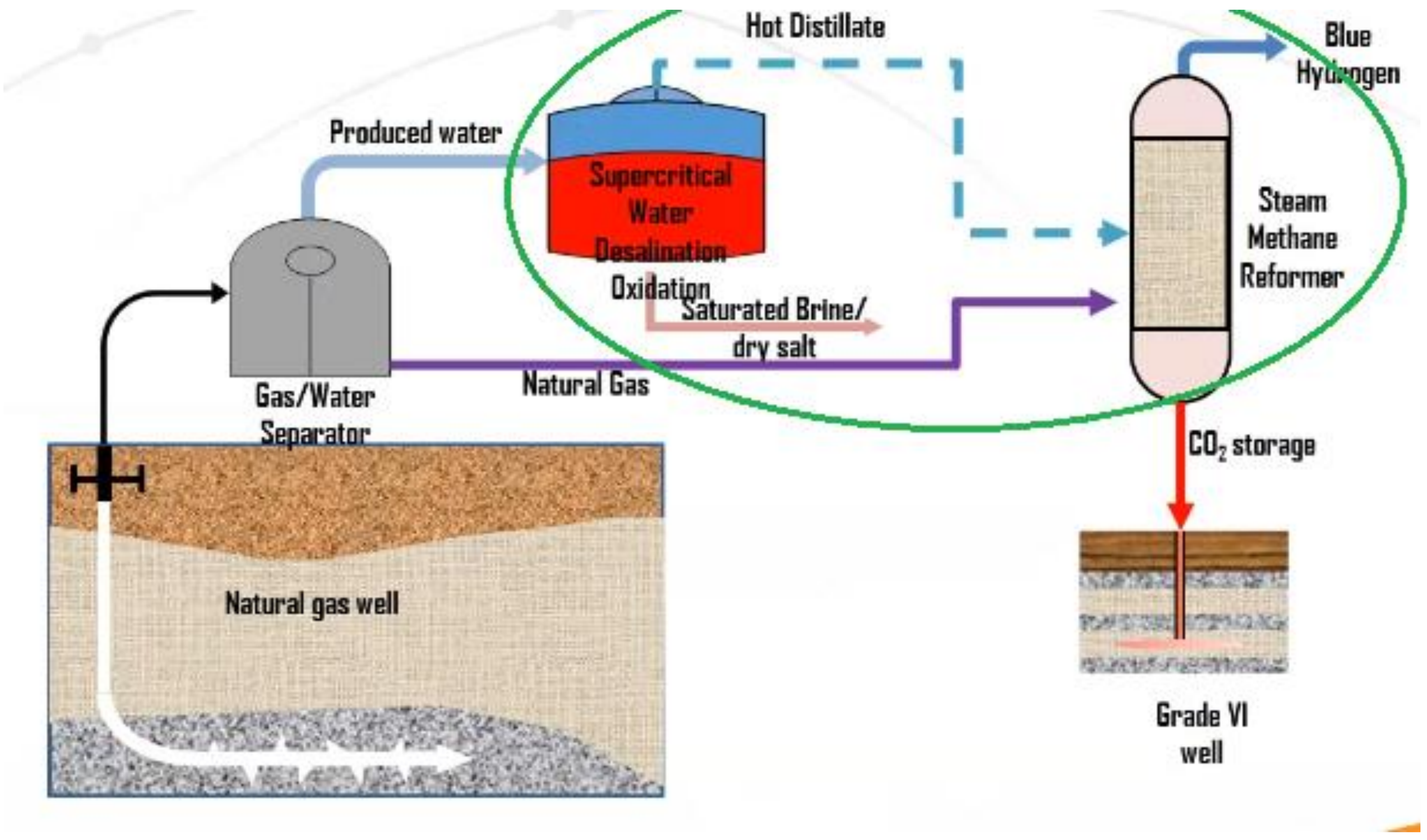

Figure 2: Cycle for supercritical water desalination and oxidation and SMR integrated unit circled in green. Image courtesy of LANL

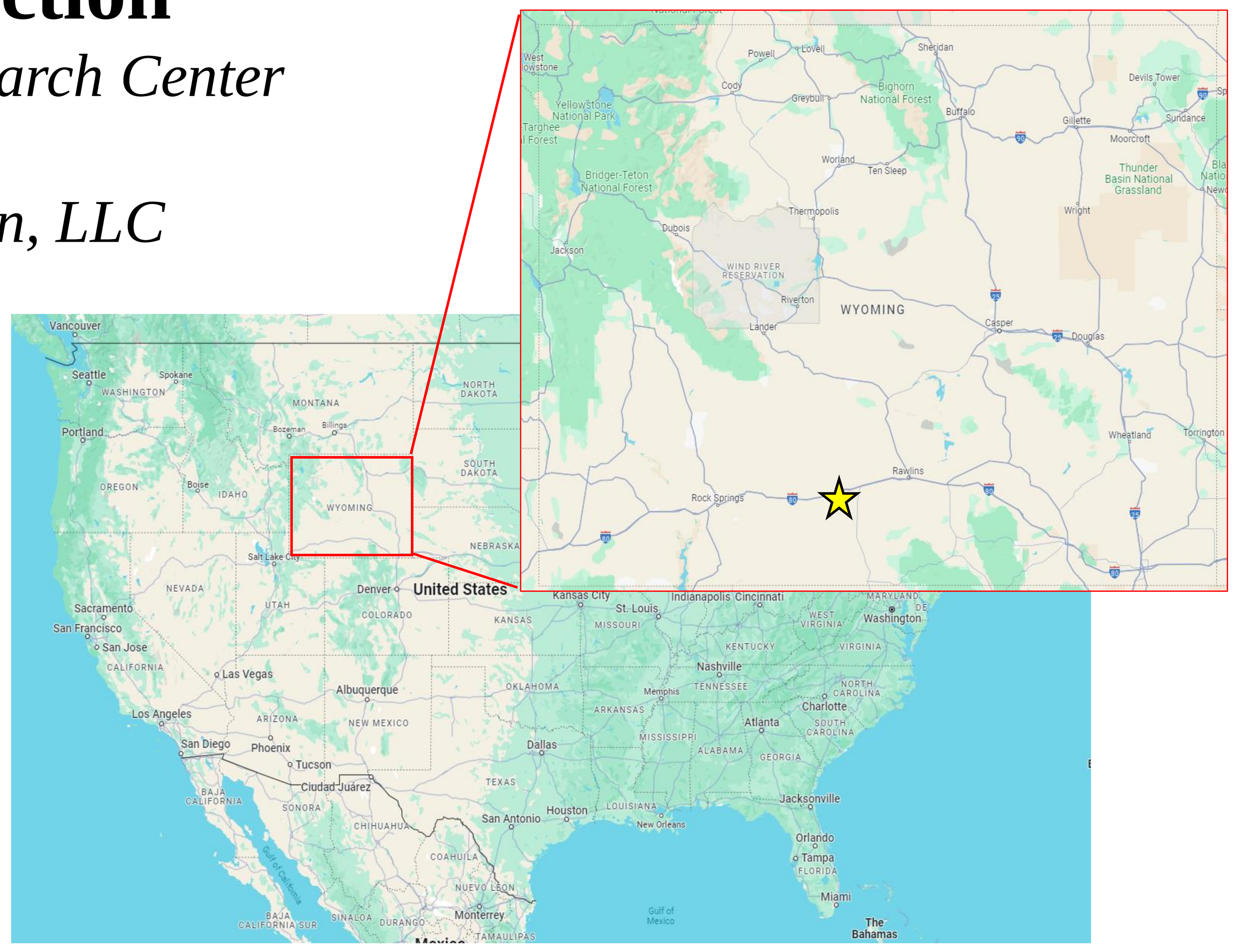

Figure 3: Location of test site near Wamsutter, WY

Approach

Los Alamos National Laboratory (LANL) will perform experiments to enable a final design. Engineering, Procurement & Construction, LLC. (EPC) in Cheyenne, WY will then fabricate the device using off-the-shelf components and test it in a controlled laboratory environment.

The device will then move to the outdoor testing location near Echo Springs and Wamsutter in south-central Wyoming (Figure 3). The device will be transported via the interstate to demonstrate mobility. This outdoor testing site is also the location of CarbonSAFE Echo Springs Phase II which may provide options for carbon capture and sequestration (CCS).

The final product will heat produced water which will then be fed through the super critical water desalination where the saturated brine will be disposed as shown in Figure 1. The supercritical water, now clean (Figure 4), will remain heated and enter the SMR unit where it will be recombined with natural gas to produce hydrogen which can then be stored or transported

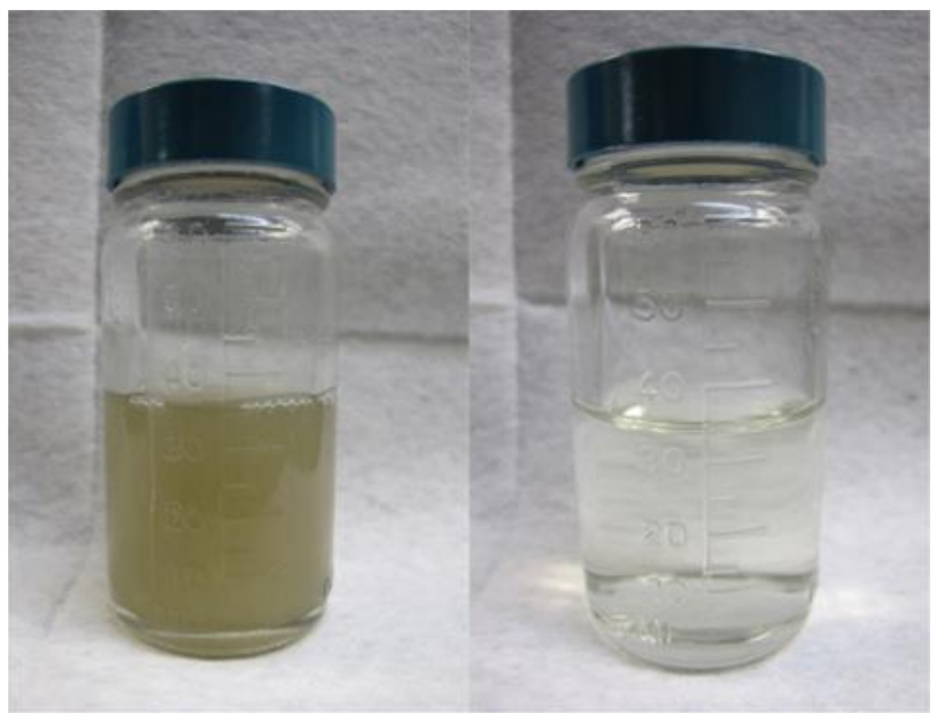

Figure 4: Produced water sample from Eagle Ford Texas (left), USA treated via the proposed SCWDO technology to generate a drinking water (right). The net salt removal was 99% and net organics removal was 100%. Image courtesy of LANL

Expected Results

This system will reduce the volume of brine (approximately 30,000 ppm salinity water roughly equal to the ocean) to about one tenth of that volume while increasing its salinity by a factor of ten. This will vastly reduce the amount of wastewater in the area and generate enough clean water of drinking-quality to produce 1 ton per day of hydrogen. Injection and disposal wells will only have to accept one tenth of the saline water they do currently. This system will make strides towards DOE's hydrogen goals by reducing the cost of water and energy needed for hydrogen production. These costs will be reduced through the integration of the SCWDO and SMR heating cycles resulting in only a single heating step, and utilizing water that was previously unusable.

Future Work:

- System to follow variable loads, throttling-back to 60% to balance the grid
- Build a full-scale system up to 1,000 tons of H2 per day
- Travel to other locations in Wyoming to demonstrate system flexibility with other water sources

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References:

1. *Doe National Clean Hydrogen Strategy and Roadmap (2023)*
2. *Sharan, P. et al. (2022). A novel approach for produced water treatment: Supercritical water oxidation and desalination. Desalination 532*