Assessment of the Potential for the Decarbonization of Natural Gas with RNG and Bioenergy with Carbon Capture and Storage

primary project goal

Oak Ridge National Laboratory (ORNL), in collaboration with the National Energy Technology Laboratory (NETL) and the Advanced Research Projects Agency–Energy (ARPA-E), is conducting an economics survey for the decarbonization of natural gas. Renewable natural gas (RNG) is a high-methane gas mixture derived from renewable biomass. RNG can be produced via a gasification or anaerobic digestion ("bio-gasification") process, followed by the methanation of syngas (a synthetic natural gas [SNG] process]). When combined with carbon capture and storage (CCS), the overall process can achieve net-zero or even net-negative carbon emissions. The objective of this study is to determine the economics of such a scheme, the point at which the life cycle emissions of such a strategy become zero, and whether or not the costs of such a scheme can compete with traditional natural gas production processes.

technical goals

- Identify a variety of potential sites for an RNG-CCS plant.
- Determine the availability of local biomass at each potential site.
- Perform a life cycle analysis (LCA) to determine carbon avoidance levels and perform a techno-economic analysis (TEA) to determine cost of avoidance.
- Develop marginal carbon avoidance cost (MCAC) curves for each location.
- Perform a sensitivity analysis for each case with respect to multiple process parameters.

technical content

The project begins with a comprehensive geologic and preliminary economics survey of more than 200 locations throughout the United States. Key fundamentals for a successful plant site have been identified as large demand for natural gas, access to existing natural gas infrastructure, and existing carbon dioxide (CO_2) transport and storage (saline reservoirs) infrastructure. Other factors to be considered include available biomass tonnage and diversity, local materials costs, and local competition from other resources. An example of a potential site in Houston, Texas is shown in Figure 1. Sites with at least five terrestrial biomass sources are being selected from this survey. A similar approach is being undertaken by ARPA-E for macroalgae biomass. The sites are being identified using the Oak Ridge Siting Analysis for Power Generation Expansion (OR-SAGE) software tool. OR-SAGE is a spatially explicit biorefinery siting model that runs as a raster analysis, excluding areas that do not meet specified criteria.

According to the 2016 Billion-Ton Report, biomass availability across the continental United States is high, and a diverse array of bioenergy resources is

program area:
Carbon Dioxide Removal

ending scale:
Laboratory Scale

application:
Biomass Carbon Removal and Storage

key technology:
Novel Concepts

project focus:
Economics Survey of Biomass-to-Natural Gas Processes with CCS

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project number:
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partners:
NETL; ARPA-E

start date:
10/01/2021

percent complete:
98%

available, as shown in Figure 2, including municipal solid wastes (MSWs), agricultural waste/residues, woody/forest biomass, and crops. This particular study also includes "wet" biomass, such as macroalgae. In total, the survey includes the following types of specific biomass species for the LCA and TEA: logging residue, whole trees, herbaceous energy crops (switchgrass), crop residues (corn stover), wastes (MSW, construction and demolition [C&D] wastes, and manure), fossil natural gas, macroalgae, and sorghum.

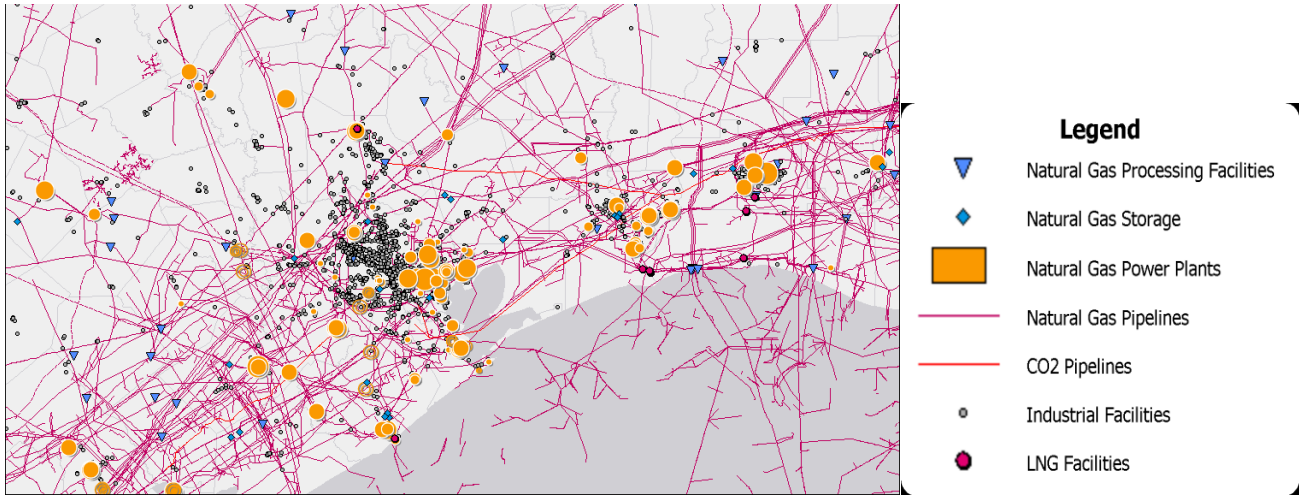

Figure 1: Sample survey location—Houston, Texas.

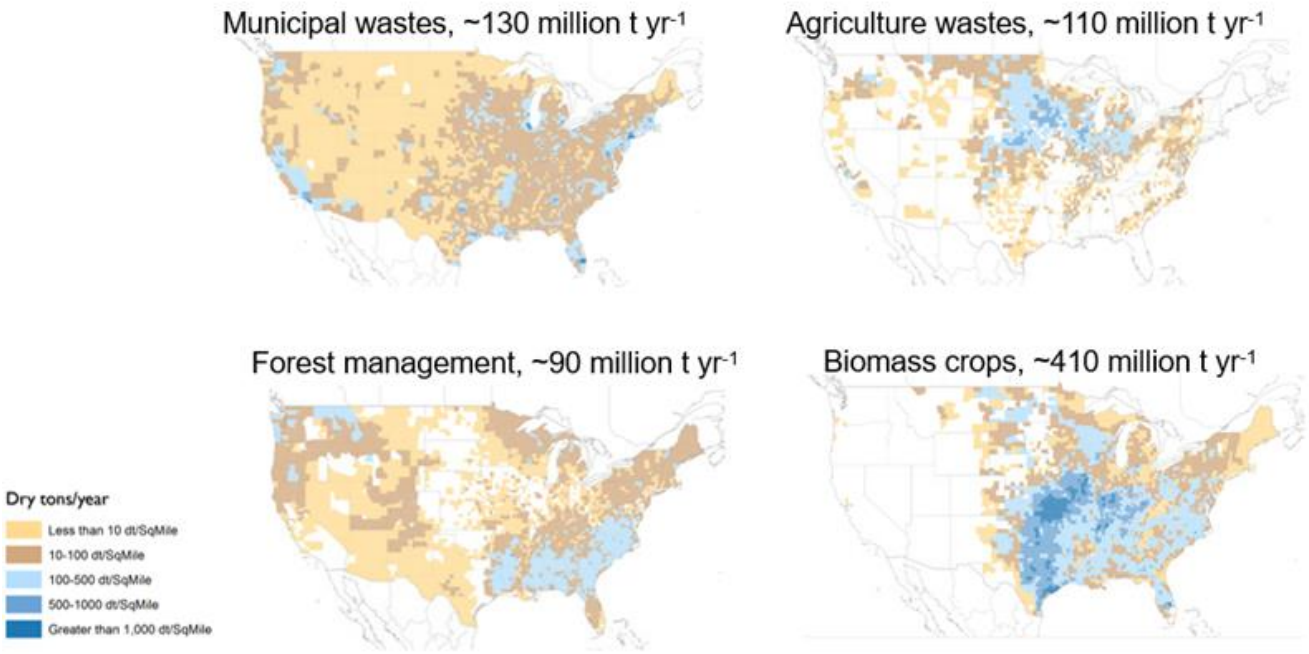

Figure 2: Biomass availabilities at $60/short ton.

ORNL is managing feedstock and site selection and analysis, as well as surveying the available conversion processes up to the point the natural gas is transported to its end-use. NETL is handling the RNG logistics for upgrading, CCS, natural gas end-use, and pipeline access, as well as being chiefly responsible for the final TEA and LCA. Finally, ARPA-E is responsible for all data for macroalgae and anaerobic digestion. The end-use for the produced RNG will explicitly be an optimized natural gas combined cycle (NGCC) plant. The baseline plant with no installed CCS serves as the baseline for all cases, which is then be compared to two CCS schemes—those being 90% and 97% capture. The complete scenario matrix for each of the parameters is given in Figure 3.

TABLE 1: MATRIX OF PARAMETERS SELECTED FOR ALL SCENARIOS

Feedstocks (ORNL/ARPA-E)	Conversion Processes (ORNL/ARPA-E)	Pipeline Transport (NETL/ORNL)	Power Production (NETL/ORNL)	CCS (NETL)
Wastes	Gasification	Natural Gas	NGCC	LCA
Ag. Residues	Pyrolysis	CO_2 (+storage)	NGCC w/ 90% CCS	TEA
Forestland Resources	Anaerobic Digestion		NGCC w/ 97% CCS	Systems/Markets
Energy Crops	CO_2 Storage Basins			
Macroalgae				

technology advantages

- Modeling of biomass resources for decarbonization.
- Quantification of carbon avoidance cost across multiple feedstock-conversion-end-use pathways.

R&D challenges

- Determining optimal site for each type of facility and facility size.
- Completing the LCA and TEA in a timely manner.
- Acquiring the necessary cost and carbon-efficiency data.

status

The project was completed on April 30, 2022.

available reports/technical papers/presentations

Langholtz, M., 2021, “RNG+NG+CCS: Assessment of the Potential for Decarbonization of NG with RNG and Bioenergy with Carbon Capture and Storage.” Project Kickoff Meeting. DOE/NETL. Pittsburgh, PA. *https://netl.doe.gov/projects/plp-download.aspx?id=11789&filename=Assessment+of+the+Potential+for+Decarbonization+of+NG+with+RNG+and+Bioenergy+with+Carbon+Capture+and+Storage.pptx*.

Bioenergy Knowledge Discovery Framework (KDF), 2016, “Billion-Ton Report - Advancing Domestic Resources for a Thriving Bioeconomy.” U.S. Department of Energy, Oak Ridge National Laboratory. Oak Ridge, TN. *https://bioenergykdf.net/2016-billion-ton-report*.