Renewable Natural Gas Resource Assessment and Co-Produced Carbon Capture and Storage: a Pennsylvania Case Study

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Abstract

This study assessed the renewable natural gas (RNG) resource potential from energy crops and waste in Pennsylvania. Operationally available feedstock from cropland under current cultivation (cover crops and crop residue) and with change in land use (cultivation of perennials on unprofitable cropland and barren, fallow/idle and riparian land); livestock (dairy cows, pigs, and chicken) manure; landfill gas; and wastewater treatment plants (WWTP) was determined. Agricultural feedstocks contributed the largest share to the RNG resource potential with crops comprising 63%, livestock manure, 12%, landfills, 23%, and WWTP, 2%. **Pennsylvania's RNG resource potential was estimated at 4.01 x 10^9 m^3/yr (57.32 Megatonnes CO_2e /yr), equal to 9.7% of the state's current natural fossil gas consumption. Avoided emissions from the production, distribution, and use of the total RNG (relative to fossil natural gas) was 15.23 Megatonnes CO_2e /yr. Co-produced CO_2 was 5.29 x 10^6 tonnes/yr for which storage capacity between 1,421 and 5,683 years exists in the state's geologic formations.** Co-digestion and inclusion of other feedstocks in Pennsylvania if collection and biosecurity concerns were addressed could improve cost-effectiveness for smaller operations while improving nutrient availability from digestate and increasing the RNG resource.

Introduction

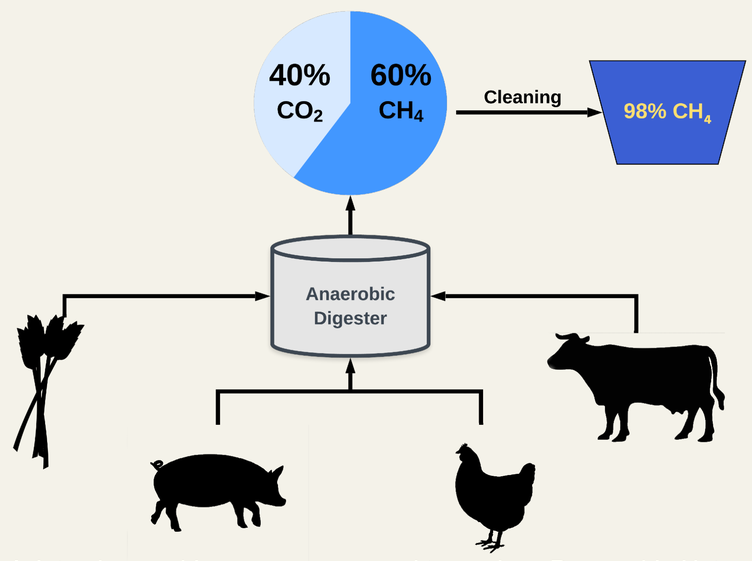


Figure 1. Interchangeable sources assessed to produce Renewable Natural Gas

Through upgrading by cleaning and conditioning, the biogas produced is converted to RNG which can be liquified or compressed for use as transportation fuel or directly injected into natural gas pipelines (Figure 1). This study seeks to determine the RNG resources available in Pennsylvania with the aim of identifying locally relevant opportunities. The state's greenhouse gas emissions have been reported to be higher than that of more than 99 countries combined, contributing about 4.2% of the anthropogenic greenhouse gas emissions in the US [1, 2]. Pennsylvania also ranks fifth among all U.S. states in CO_2 emissions from direct fuel use across all sectors [3]. This study also fits into the state's Climate Action Plan as climate impacts have been reported to be already occurring and put local industries and human health at risk [4].

Objectives

- **Determine potential RNG production in Pennsylvania from the targeted agricultural and non-agricultural sources listed below:**
  - **Livestock manure** – Dairy cows, pigs, and chicken
  - **Crop** – perennials, cover crops, and crop residue;
    - Corn stover harvest on profitable corn land
    - Double-crop on profitable annual corn land (rye and corn stover)
    - Barren land going to perennials
    - Fallow/Idle and unprofitable cropland going to perennials
    - Riparian land to perennials
  - **Landfill gas**
  - **Wastewater Treatment Plant**
- Quantify key environmental benefits of reducing greenhouse gas emissions especially from livestock manure, offsetting fossil fuel emissions, and increasing carbon capture and storage potential
- **Prepare results for utilization of optimization model to identify optimal RNG production and sequestration geology for future study**

Feedstock Inventorying

- Feedstocks were inventoried utilizing primarily government inventorying agencies summarized below:
- **United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS)**
  - Livestock Manure
  - Crops
    - CropScape additionally accessed
- **United States Environmental Protection Agency (USEPA)**
  - Landfills
  - Wastewater Treatment Plants (WWTP)
- **United States Geological Survey (USGS)**
  - CO_2 geological sequestration sites

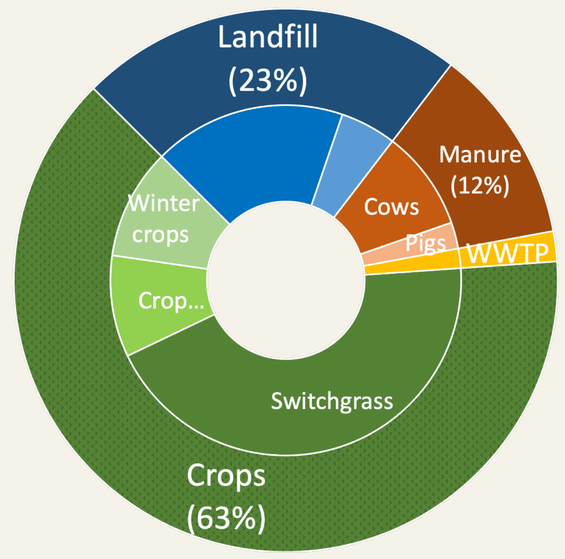


Figure 2. Cumulative distribution of potential RNG production by feedstock

Results

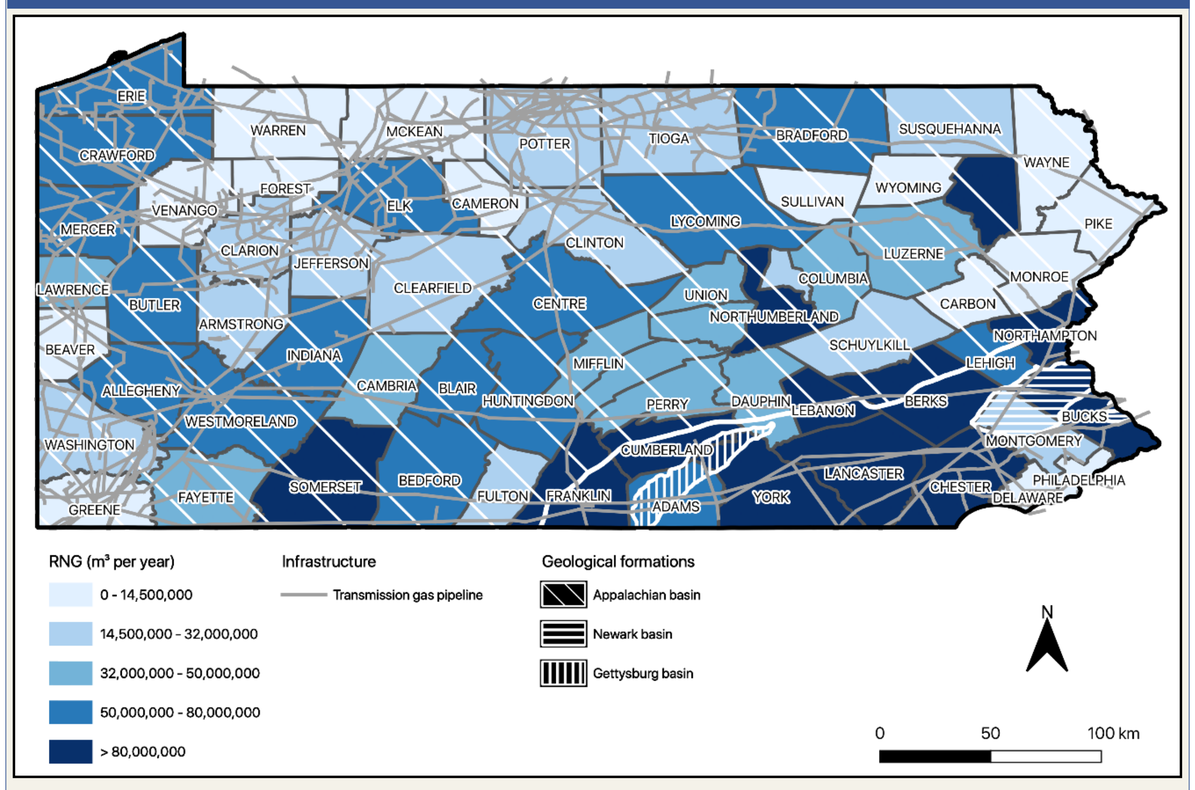


Figure 3. Renewable Natural Gas potential and natural gas and CO_2 sequestration infrastructure

- **Pennsylvania's resource potential for RNG generation from crops (switchgrass and rye) and waste (corn stover, manure, landfill gas, and WWTPs) was estimated as 4.01 x 10^9 m^3/yr, equal to about 9.72% of the state's current natural gas consumption.**
- Storage capacity of between 1,421 and 5,683 years exist in the state's geologic formations for the co-produced CO_2 of 5.29 x 10^6 tonnes/yr.
- Reduced greenhouse gas emissions from RNG production, distribution and use relative to natural gas was, 15.20 x 10^6 tonnes CO_2e/yr.

Conclusions and Future Work

- **Feedstocks were concentrated on the east of the state where five counties with the highest RNG resource contributed 30% to the state's total.**
- Agricultural feedstocks contributed the highest RNG potential. Future estimates may consider temporal variation in plant biomass.
- **Other feedstocks abundant in Pennsylvania could help achieve economy of scale for smaller operations whose feedstock quantities are too small to be cost-effective.**
- Existing and developing pipeline infrastructure, sustainable energy marketplace incentives, and biosecurity will help increase RNG availability to end-users.

References

[1] Ritchie H. and Max R. 2017. CO_2 and Greenhouse Gas Emissions.
[2] EPA (U.S. Environmental Protection Agency). 2018. Inventory of U.S. Greenhouse Gas Emissions and Sinks.
[3] U.S. Energy Information Administration. 2020. Energy-Related CO2 Emission Data Tables.
[4] Pennsylvania Department of Environmental Protection (PADEP), 2019. Pennsylvania Climate Action Plan 2018: Strategies and action to reduce and adapt to climate change.