Optimizing Production of Renewable Natural Gas (RNG) to Support a Reformed Landscape

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Stephanie Taboada[1,2], Lori Clark[2,3], Jake Lindbeg[1,4], David Tonjes[2,3,4] , Devinder Mahajan[1,2]
[1]Department of Materials Science and Chemical Engineering, Stony Brook University, Stony Brook, NY 11794, USA
[2]Institute of Gas Innovation and Technology, Advanced Energy Research and Technology Center, Stony Brook University, Stony Brook, NY 11794, USA
[3]Department of Technology and Society, Stony Brook University, 100 Nicolls Rd, Stony Brook, NY 11794, USA
[4]Waste Date and Analysis Center, Stony Brook University, 100 Nicolls Rd, Stony Brook, NY 11794, USA

Introduction

Global climate change resulting from the use of fossils fuels to generate electricity is the defining issue of our times. Natural gas has been defined as the "bridge" energy source because it produces fewer greenhouse gas emissions (GHGs) than other fossil fuels. RNG is "carbon neutral," meaning the carbon emissions it releases does not add to the existing carbon cycle as fossil fuels do. RNG has the same chemical structure as fossil natural gas. Therefore, RNG can substitute natural gas in the existing gas grid.

RNG is produced by upgrading biogas, leaving behind 95% or greater methane content. Biogas is produced through the anaerobic digestion of organic material from animal waste, energy crops, municipal solid waste (MSW), agricultural residues, wastewater treatment plant (WWTP) sludge, yard waste, and paper mill sludge.

Our intention here is to describe the potential to reduce the GHG impact of natural gas through RNG production. RNG production and use are impacted by available gas generating stocks, technology choices, and policy environments, and so are particular to certain places and times. We therefore are going to ground our concepts through a careful examination of current and potential RNG production in New York State (NYS), something we accomplished on a smaller scale for Long Island [1]. The lessons learned from the idiosyncrasies of NYS can be applied to draw broader conclusions regarding general prospects for RNG and the natural gas grid.

Objectives

- To calculate the RNG production potential in NYS from the following resources and determine how much RNG could replace current fossil natural gas demand in NYS:
  - Dairy manure
  - Poultry manure
  - Energy crops
  - Other agricultural residues
  - WWTP sludge
  - Landfilled MSW
  - Other food waste
  - Composted yard waste
  - Paper mill sludge

Methods

Table 1. shows how the biogas and RNG production potential was calculated. Current biogas production values and RNG production values were collected from credible sources (i.e. Environmental Protection Agency, NYS Department of Environmental Protection, etc.) In some cases, such as when calculating agricultural residues, I assumed 50% of the waste produced from energy crops would be used as cover for soil protection and the remaining 50% would be used for to produce RNG.

Table 1. Calculation of annual potential biogas and RNG production

Potential Biogas Production		$Y_{biogas} = Q_{resource} \times VS_{resource} \times B_{biogas}$
Potential RNG Production		$Y_{RNG} = Q_{resource} \times VS_{resource} \times B_{biogas} \times 0.5$
Y_{biogas}	=	Total annual potential biogas produced per resource
Y_{RNG}	=	Total annual potential RNG produced per resource
$Q_{resource}$	=	Yearly amount of each resource
$VS_{resource}$	=	% of volatile solids (VS) per resource
B_{biogas}	=	Amount of biogas produced per VS content of each resource
0.50	=	Amount of RNG produced from biogas

Results and Discussion

The value for RNG shown in Table 2 was generated assuming biogas is approximately 50% methane, and RNG is 100% methane (and there is no loss of methane in upgrading biogas to RNG). Note that agricultural crop waste is the largest potential source of RNG by an order of magnitude. Crops grown specifically to provide energy are the next largest source, five times greater than landfilling. The other waste categories sum to approximately as much as the landfilling generation rate. Food waste, if entirely source separated and treated through anaerobic digestion, might contribute one-third of the waste biogas potential, one-tenth of the potential from specific energy cropping and about as much as residues from standard NYS agriculture. Together, all manures and sludges have a potential biogas production rate that is two-thirds that of NYS landfills.

Annual NYS consumption of natural gas is approximately 40 x 10^9 m^3 [2]. The estimate here is that agricultural and waste sectors together could potentially provide about 6% of this demand. NYS would need to change practices in several important ways to achieve this: develop a robust energy crop industry, efficiently collect agricultural residues and manage them through anaerobic digestion and divert yard waste to from composting. Energy crop production is most important: it accounts for about two-thirds of the potential to produce biogas.

Table 2. Annual potential biogas and RNG production for NYS by resource [3], [4], [5], [6].

Resource	Potential Biogas Production (m^3)	Potential RNG Production (m^3)
Dairy Manure	$3x10^8$	$1.5x10^8$
Poultry Manure	$1x10^7$	$5x10^6$
Energy Crops	$3.3x10^9$	$1.7x10^9$
Other Agricultural Residues	$4x10^8$	$2x10^8$
Total Agricultural Waste	**$4x10^9$**	**$2x10^9$**
Wastewater Treatment Plant Sludge	$5.5x10^7$	$3x10^7$
Landfilled MSW	$5x10^8$	$2.5x10^8$
Other Food Waste	$1.7x10^8$	$1x10^8$
Currently Composted Yard Waste	$5x10^8$	$2.5x10^8$
Paper Mill Sludge	$4x10^7$	$2x10^7$
Total Wastes Output	**$1.3x10^9$**	**$6x10^8$**
Total	**$5x10^9$**	**$2.5x10^9$**

The primary producers of biogas in NYS are landfills (Table 3). Manure, food wastes, and WWTP sludges produce less than 5% of the landfill output. All the current production of RNG produced in NYS is at landfills.

Although crop residues were identified as the greatest potential source of biogas in NYS, there is no significant utilization of the resource. Although RNG has practical, environmental, and economic advantages for using biogas, only 10% of the generated biogas resource is currently upgraded to RNG.

Currently NYS generates a third of its potential biogas production from wastes because landfills are the most important element there, and regulation promotes the recovery of biogas from landfills. If the technologically feasible resources from Table 3 were entirely exploited as RNG, which seems to be economically advantageous, then more than 10 times current RNG production could be realized (approximately 1% of NYS natural gas demand).

Results and Discussion (cont.)

Table 3. Annual biogas and RNG production for NYS by resource

Resource	Biogas Production (m^3)	RNG Production (m^3)	Potential RNG Production (m^3)
Dairy Manure	$2x10^7$		$1.5x10^8$
Poultry Manure	$9x10^5$		$5x10^6$
Total Agricultural Output	**$2x10^7$**		**$1.5x10^8$**
Wastewater Treatment Plant Sludge	$4x10^6$		$3x10^7$
Landfilled MSW	$4x10^8$	$4x10^7$	$2.5x10^8$
Other Food Waste	$2x10^7$		$1x10^8$
Total Wastes Output	**$4x10^8$**	**$4x10^7$**	**$3.5x10^8$**
Total	**$4x10^8$**	**$4x10^7$**	**$5x10^8$**

Conclusions

- NYS collects about 10% of its potential biogas output currently, and only processes a small fraction of the biogas to RNG.
- Managing energy crops and agricultural residues through anaerobic digestion can produce the largest amounts of RNG. Areas with more crop agriculture than NYS could be well-suited to creating robust RNG generation.
- Landfills offer a great opportunity to produce RNG. Adding yard waste to this industry would increase production further.
- Substituting all potentially produced RNG for fossil natural gas in NYS would reduce annual carbon emissions associated with natural gas use there by approximately 6%, which is equivalent to 5 million tons of carbon dioxide.

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