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RENEWABLE NATURAL GAS IN A MINNESOTA CLEAN FUELS POLICY

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This case study, prepared by the Great Plains Institute, explores how renewable natural gas could perform in a Minnesota clean fuels policy.

What is the Minnesota clean fuels policy?

Led by the Great Plains Institute, the Minnesota clean fuels policy (CFP) is a proposed market-based policy to reward any fuel that could offer a greenhouse gas advantage in the transportation sector, without picking winners or losers. It would reduce the use of higher-carbon fuels and support commercial deployment of lower-carbon fuels, including biofuels, natural gas, and electricity for vehicles.

A CFP, like the California Low Carbon Fuel Standard, sets a standard for reduced carbon intensity of transportation fuels over time, otherwise known as a baseline carbon intensity standard. Carbon intensity is a measure of the greenhouse gas emissions associated with the production of a specific fuel. Fuel producers receive incentives in the form of credits from lowering their carbon intensity through production process efficiency improvement, switching to lower-carbon fuel or feedstocks, and other mechanisms that decarbonize the supply chain. These changes reduce overall greenhouse gas emissions in the transportation sector. Fuel producers that do not meet the annual standard must purchase alternative fuel or credits to comply with the program while those that are under the standard generate credits based on the carbon reduced, creating an "opportunity zone" as demonstrated in figure 1.

Figure 1. Clean fuels policy market logic

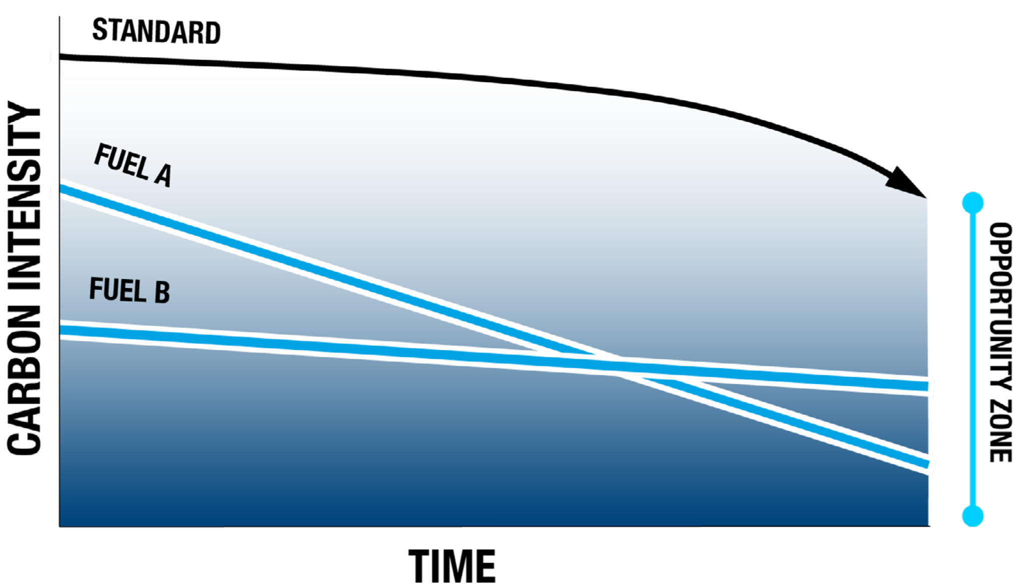


Figure 1 shows the carbon intensity of the standard becoming more stringent over time and two example low carbon fuel pathways, Fuel A and Fuel B. Carbon intensities below the standard create an "opportunity zone," where the lower-carbon fuel pathway generates market credits. As the standard gradually declines, there are additional opportunities to reduce the carbon intensity of lower carbon fuel pathways through improvements in the supply chain. Fuel A shows a decline in carbon intensity over time consistent with the gradual reduction of the standard, ensuring that the opportunity for Fuel A to generate market credit stays constant. Fuel B declines only slightly over time, indicating that the opportunity zone for credit generation becomes slightly smaller.

TYPES OF NATURAL GAS

SOURCES AND PRODUCTION PROCESSES

Natural gas is used as a transportation vehicle fuel in both liquefied and compressed gaseous forms. The carbon intensity for natural gas, a calculation of the greenhouse gas emissions associated with its production and use, depends on its source and the energy used in processing the raw fuel into liquid or compressed form. The types of natural gas are identified below, and table 1 further describes the types examined in this case study.

Conventional natural gas (NG) is a fossil fuel primarily comprised of methane. Natural gas is drawn from wells and often gathered as a byproduct of crude oil extraction.

Renewable natural gas (RNG) is produced from the gas byproduct of organic matter decomposition or anaerobic digestion and is fully interchangeable with conventional natural gas when processed to achieve purity standards. RNG can be sourced from landfills and anaerobic digesters that use manure, food waste, biosolids, and other organic materials as feedstocks. It must be compressed or liquefied before it can be used in vehicles.

Compressed natural gas (CNG) is produced by compressing conventional or renewable natural gas to less than 1 percent of its volume.

Liquefied natural gas (LNG) is produced by super-cooling conventional or renewable natural gas into a liquid form. The natural gas remaining is primarily methane with small amounts of other hydrocarbons. It is a growing, but small, part of the RNG market and is not modeled in this case study.

MODELING CARBON INTENSITY

As of 2017, there were approximately 175,000 natural gas vehicles in the United States. Natural gas vehicles are available in all varieties, including passenger cars, but are most commonly medium- and heavy-duty vehicles such as trucks, work vehicles, and buses. Because natural gas is primarily used in heavier-duty vehicles, it is modeled against the diesel standard instead of gasoline in this case study.

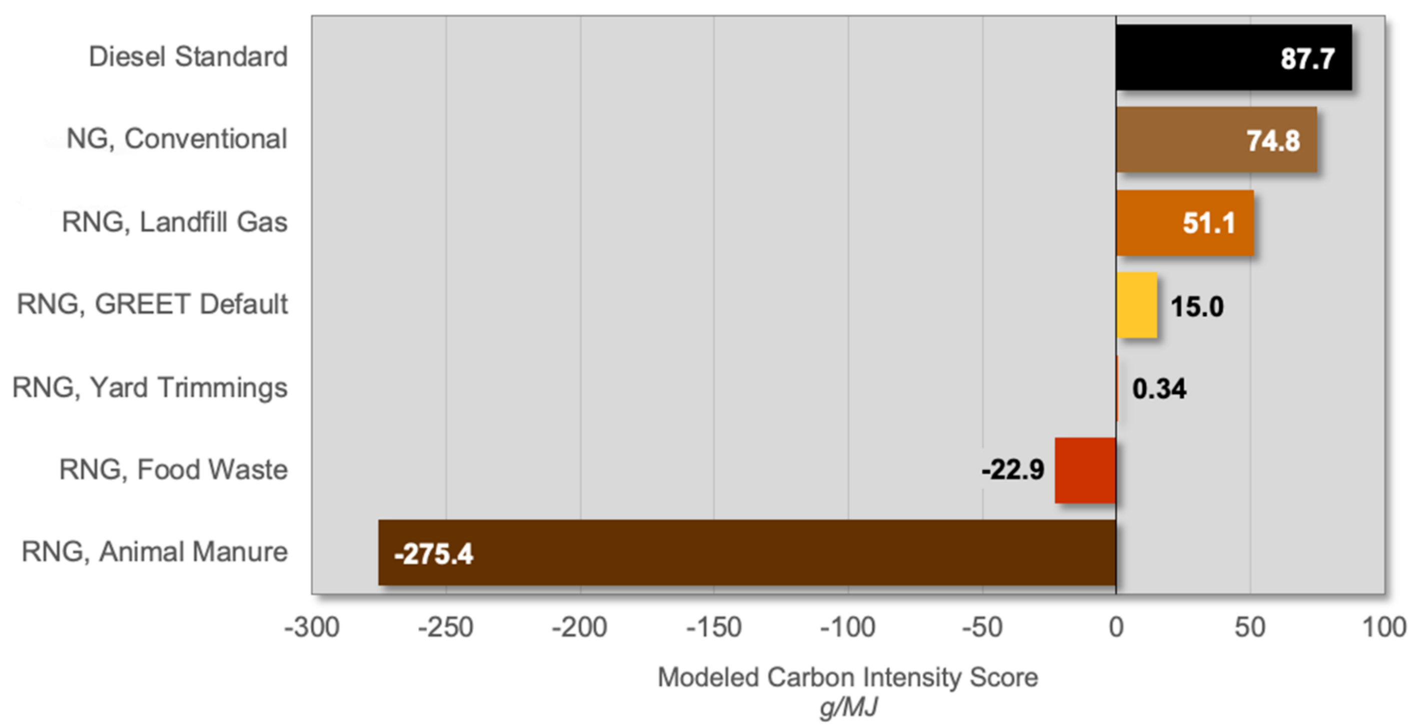
Quantities of compressed natural gas are measured in standard cubic feet (scf), which is the amount of gas needed to fill a volume of one cubic foot under standard pressure and temperature. About 144 scf of natural gas provides the same energy as one gallon of diesel fuel.

Figure 2 shows the carbon intensity of several natural gas fuel pathways: conventional NG, default RNG, and four feedstock-specific RNG pathways using yard waste, animal manure, food waste, and landfill gas. The figure demonstrates that a given fuel, such as RNG, has varying CI scores based on feedstock and processes used to produce the fuel. CI scores can also be influenced by a variety of criteria under existing clean fuels policies, like California's Low Carbon Fuel Standard (LCFS). For example, the LCFS rewards RNG that diverts methane from landfills and lagoons, which is how some RNG pathways can achieve negative CI scores. In Minnesota, a facility-specific lifecycle assessment would need to be submitted to provide a carbon intensity for use in a local clean fuels market. Carbon intensity scores are reported in grams of carbon dioxide equivalent per megajoule (CO2e g/MJ) to compare fuels on an equivalent energy basis.

Table 1. Conventional and renewable natural gas pathways for transportation fuels modeled in figure 2

FUEL	DESCRIPTION
Diesel standard	Used as baseline fuel.
NG, Conventional	Typically drawn from wells or extracted as part of the crude oil production process.
RNG, GREET Default	A default renewable natural gas pathway calculated using Argonne National Laboratory's GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model 2018.
RNG, Yard Trimmings	Renewable natural gas produced through anaerobic digestion of yard waste (such as yard trimmings).
RNG, Animal Manure	Renewable natural gas produced through anaerobic digestion of animal manure.
RNG, Food Waste	Renewable natural gas produced through high-solids anaerobic digestion of food waste and organics.

Figure 2. Carbon intensity (CI) scores of renewable natural gas pathways compared to the diesel standard and conventional natural gas



Source: The Great Plains Institute produced these scores using a version of Argonne National Laboratory's GREET model and are based on facilities throughout the United States that have registered a lifecycle carbon intensity score with the California Air Resources Board for participation in the California Low Carbon Fuel Standard.

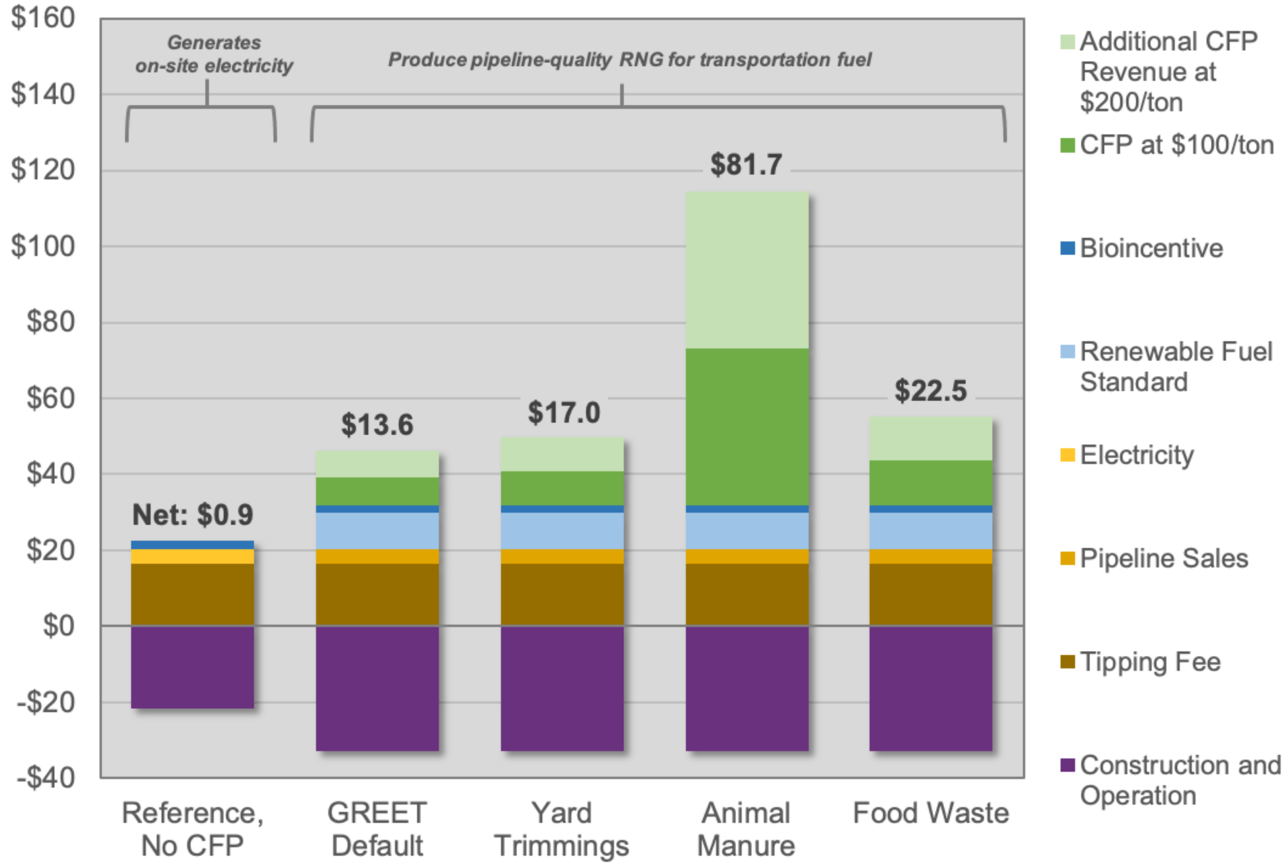
ECONOMICS OF AN ANAEROBIC DIGESTION FACILITY IN A CLEAN FUELS MARKET

As our case study showed, RNG produced through anaerobic digestion offers greenhouse gas emission reductions compared to conventional natural gas and the diesel standard in a clean fuels market. To further understand a clean fuels policy's impact on the economics of RNG production at anaerobic digestion facilities and landfills, we modeled three scenarios for RNG production revenue:

1. No clean fuels policy
2. Clean fuels policy with $100/ton credit value
3. Clean fuels policy with $200/ton credit value

This case study shows the potential revenue that facilities producing RNG with the carbon intensities from figure 2 could generate under a CFP. It assumes that the facility manages 50,000 tons of waste per year and would receive the credit value from a Minnesota clean fuels credit market, though credit allocation will depend on the specific clean fuels policy design. Figure 3 shows the annual costs and revenues for facilities achieving carbon intensity scores similar to those for existing RNG feedstocks, including potential revenue from a clean fuels policy. Table 2 shows the annual net income for the modeled scenarios, and figure 4 further breaks down the net income in dollars per MMBtu for each facility type.

Figure 3. Cost and revenue breakdown for RNG production by feedstock with example CFP credit generation (in $/MMBtu)



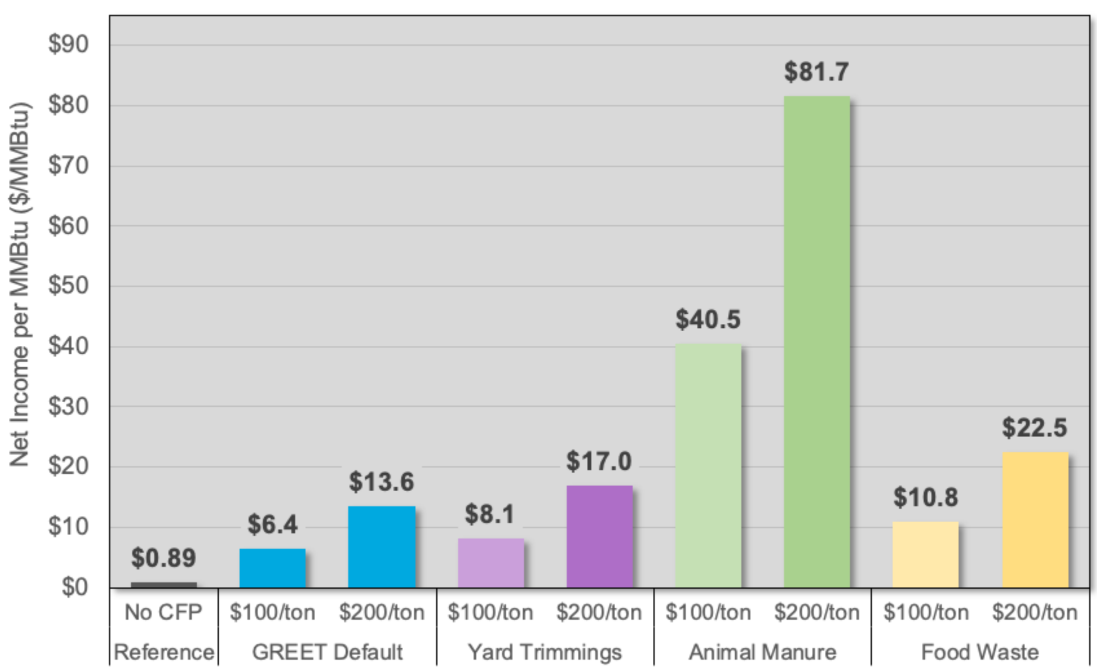
Source: Based on Great Plains Institute, Anaerobic Digestion Evaluation Study (September 2018), http://morevalue-lesstrash.com/s/Anaerobic-Digestion-Evaluation-Study-22l9.pdf. Theoretical CFP credit generation is calculated from Midwestern anaerobic facilities with registered lifecycle carbon intensity scores conducted with Argonne National Laboratory's GREET lifecycle model and published for the California LCFS.

Table 2. Annual Net Income for 50 Thousand TPY Anaerobic Digestion (AD) Facility by Feedstock

RNG Carbon Intensity Case	AD Facility Generating Electricity with No CFP	AD Facility Selling Fuel to CFP Market Credit Price: $100 per ton CO2	AD Facility Selling Fuel to CFP Market Credit Price: $200 per ton CO2
Reference	$44,000	$0	$0
GREET Default	$44,000	$320,000	$679,000
Yard Trimmings	$44,000	$406,000	$851,000
Animal Manure	$44,000	$2,023,000	$4,084,000
Food Waste	$44,000	$542,000	$1,123,000
			net income per year

Note: Without a CFP, all AD facilities use biogas to generate electricity, resulting in the same income per MMBtu. For simplicity, biogas yields are assumed to be the same for 50 thousand tons of waste from each feedstock.

Figure 4. Net income per MMBtu of RNG from anaerobic digestion of various feedstocks ($/MMBtu)



Source: The Great Plains Institute produced these scores using a version of Argonne National Laboratory's GREET model and are based on facilities throughout the United States that have registered a lifecycle carbon intensity score with the California Air Resources Board for participation in the California Low Carbon Fuel Standard.

OPPORTUNITIES FOR NATURAL GAS IN A CLEAN FUELS POLICY

GENERATING CREDITS AND VALUE

Credits are generated by fuels with carbon intensities lower than the standard, which declines over time based on the policy determination. The difference between a fuel's carbon intensity (CI) and the CI set by the standard in any given year determines the credits it can generate. The dollar value of credits varies according to market forces but would be expected to be between $100 and $200 per ton in a Minnesota clean fuels policy based on modeling conducted by ICF for the Midwestern Clean Fuels Policy Initiative[1], which will be published in a forthcoming report. Table 3 shows theoretical credit values generated by the modeled types of natural gas under a mid-point 3.4 percent reduction from the initial baseline for a policy that would aim to achieve a 15 percent CI reduction by the end of the reduction period. The policy would determine the actual allocation and distribution of credits to appropriate entities, including the vehicle operator and processing facility.

Table 3. Snapshot of credit values generated by natural gas pathways at a mid-point 3.4% CI reduction

FUEL	CREDIT GENERATION POTENTIAL for credit values: $100 - $200 / ton
NG, Conventional	$0.17 - $0.34 MCF
RNG, GREET default	$7.18 - $14.36 MCF
RNG, Landfill Gas	$2.95 - $5.90 MCF
RNG, Yard Trimmings	$8.90 - $17.80 MCF
RNG, Animal Manure	$41.23 - $82.46 MCF
RNG, Food Waste	$11.62 - $23.25 MCF

Note: credit value assumes a market price of $100/ton and $200/ton. MCF is equal to 1,000 standard cubic feet. Credit values were calculated by GPI.

ACHIEVING ECONOMIC AND ENVIRONMENTAL GOALS THROUGH A MINNESOTA CLEAN FUELS POLICY

As shown in this case study, Minnesota stands to gain economic and environmental benefits from a clean fuels policy, even more so than California has from its long-running low carbon fuel standard. The California standard has provided growth opportunities for lower-carbon fuels, including significant value for Midwestern low-carbon fuels exported to California. A Minnesota clean fuels policy, through a technology-neutral and performance-based approach, has the potential to use similar market-based mechanisms to develop demand growth in this region without the need to import fuel. Establishing a clean fuels policy in Minnesota would aid in developing more clean fuel projects and keep environmental benefits like greenhouse gas emission reductions here. It would also reduce reliance on federal policy and policy makers in other states and retain autonomy for Minnesota.

For more information and to stay updated on this effort, contact Brendan Jordan at bjordan@gpisd.net or visit www.betterenergy.org.

[1] *The Midwestern Clean Fuels Policy Initiative brings together a diverse group of stakeholders to help create economic benefits for the region through policy, research, and education on the production and use of cleaner fuels. The Initiative is facilitated by the Great Plains Institute, a nonpartisan, nonprofit organization that is transforming the energy system to benefit the economy and environment.*