Economic Analysis of the US Renewable Natural Gas Industry

December 2022

THE COALITION FOR RENEWABLE NATURAL GAS

Key Assumptions & Methodology

Data Sources: RNG facility capacity and cost information (e.g., volume and status) provided by The Coalition for Renewable Natural Gas.

Data reflects the annual operational capacity of facilities (e.g., MMBTUs), capital expenditures of facilities under construction, and planned number of facilities as of October of 2022.

Economic modeling of capital expenditures and operational production capacity was conducted using IMPLAN software.

Note: Many of the significant changes seen between this update and the previous study (completed in December 2021) are a result of improved data collection and therefore should be carefully considered in terms of indicative trends.

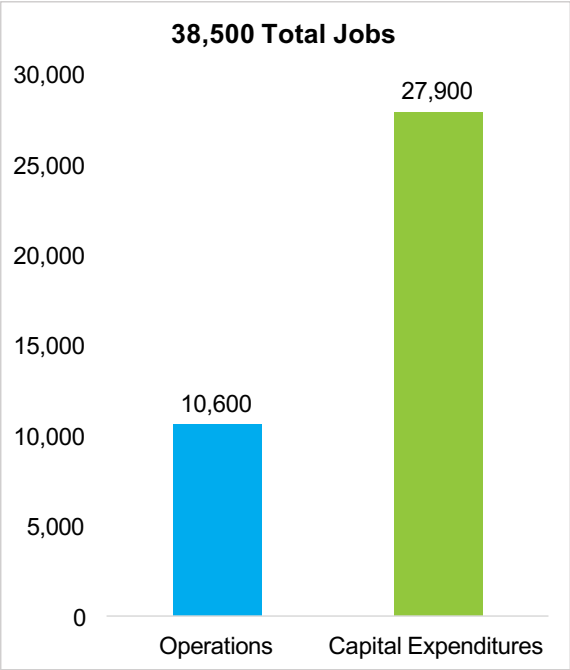
Executive Summary

THE COALITION FOR
RENEWABLE
NATURAL GAS

Highlights from 2022

Renewable natural gas (RNG) is estimated to contribute 38,500 in jobs, $4.8B in GDP, and $9.5B in total business sales in 2022 based on RNG operational capacity and expected capital expenditures

These numbers include the direct, indirect, and induced economic impacts of RNG. Capital expenditures represent jobs (27,900) associated with facilities currently under construction and only persist for the construction timeline. Operational jobs (10,600) are for the current year 2022 and are anticipated to continue into future years.



Highlights from 2022

Although it is a relatively small industry today, RNG has the potential to create thousands of jobs

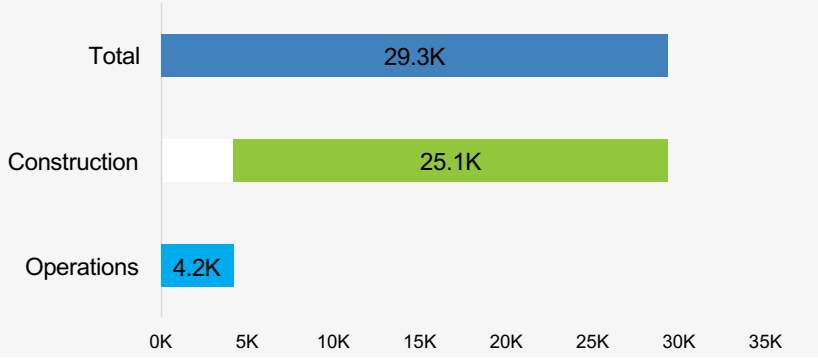
RNG facilities support the creation of operational jobs. The construction of 100 new RNG facilities would support 25,100 construction jobs and 4,200 operational jobs.

1.6 operations jobs are created for every $1 million spent on RNG production in 2022

22 operations jobs are created per 1 million MMBTUs of RNG generated in 2022

2 operations jobs created per 1 million EGE of RNG produced in 2022

100 new RNG facilities create an average of 4,200 operations jobs and 25,100 construction jobs



Highlights from 2022

Construction jobs vary by RNG feedstock

Construction of a wastewater project creates an average of 268 total jobs, an agricultural waste project an average of 216 total jobs, a food waste project an average of 424 total jobs, and a MSW project an average of 328 jobs.[1]

Construction of a wastewater project creates an average of:

109 direct jobs
63 indirect jobs
97 induced jobs

268 total jobs

Construction of an agricultural waste project creates an average of:

88 direct jobs
50 indirect jobs
78 induced jobs

216 total jobs

Construction of a food waste project creates an average of:

172 direct jobs
99 indirect jobs
153 induced jobs

424 total jobs

Construction of a MSW project creates an average of:

115 direct jobs
85 indirect jobs
129 induced jobs

328 total jobs

[1]Calculations are based on the average jobs per facility under construction for each feedstock in 2022. These numbers were provided by the RNG Coalition.

Highlights from 2022

Operations and maintenance jobs, across the supply chain, vary by RNG feedstock

Across the full supply chain, operation and maintenance of a wastewater project creates an average of 18 total jobs, an agricultural waste project an average of 16 total jobs, a food waste project an average of 41 total jobs, and a MSW project an average of 91 jobs.[1]

Operation and maintenance of a wastewater project creates an average of:

3 direct jobs
7 indirect jobs
8 induced jobs

18 total jobs

Operation and maintenance of an agricultural waste project creates an average of:

3 direct jobs
6 indirect jobs
7 induced jobs

16 total jobs

Operation and maintenance of a food waste project creates an average of:

8 direct jobs
15 indirect jobs
18 induced jobs

41 total jobs

Operation and maintenance of a MSW project creates an average of:

17 direct jobs
33 indirect jobs
40 induced jobs

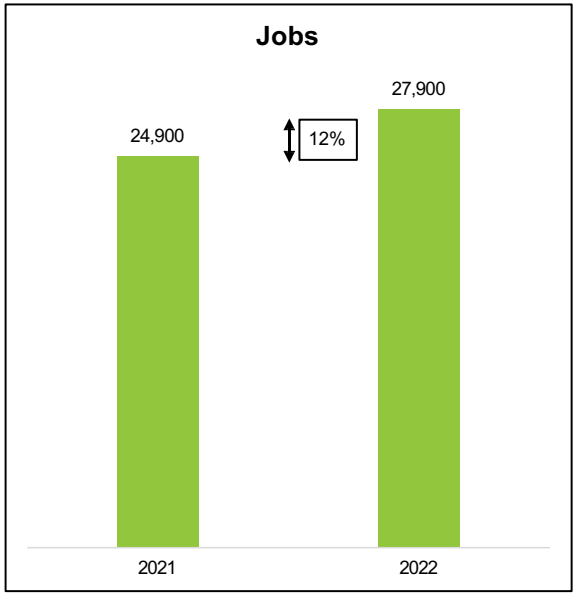
91 total jobs

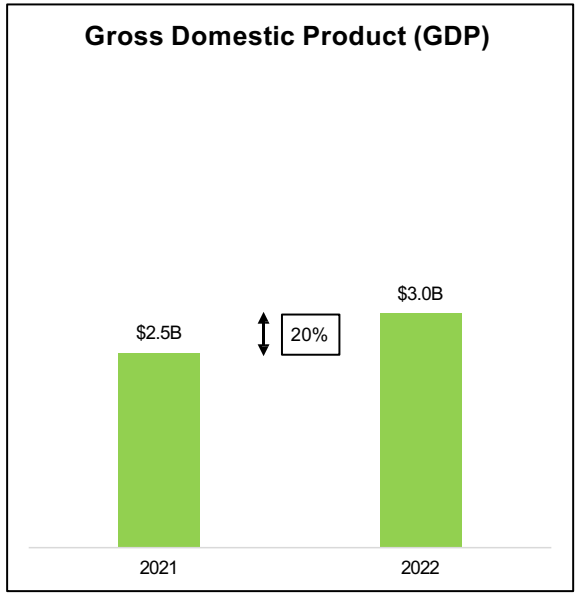
[1]Calculations are based on the average jobs per operating facility for each feedstock in 2022. These numbers were provided by the RNG Coalition.

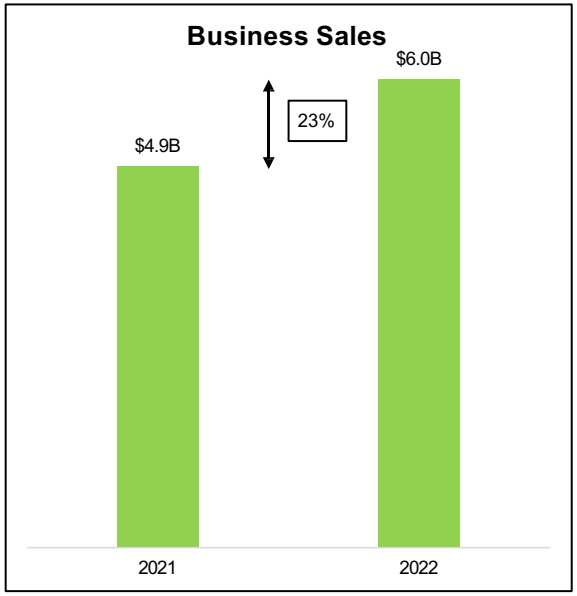
Comparison between 2021 and 2022

Economic impacts: capital expenditures

The economic impacts associated with RNG facilities under construction increased by 12% for jobs, 20% for GDP, and 23% for business sales between 2021 and 2022. This increase is driven by changes in the number of facilities, the amount of MMBTUs per facility, changes in costs, and increased inflation.



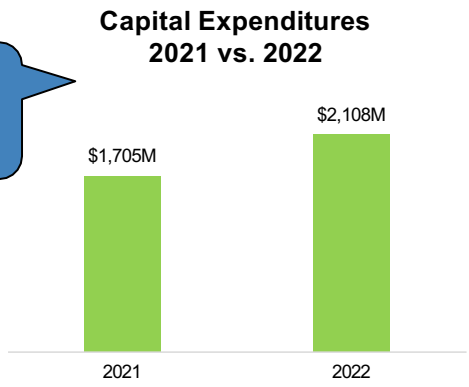


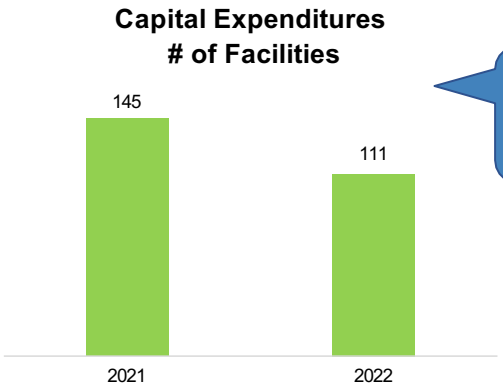


Comparison between 2021 and 2022

Capital expenditures by facility increased from 2021 to 2022

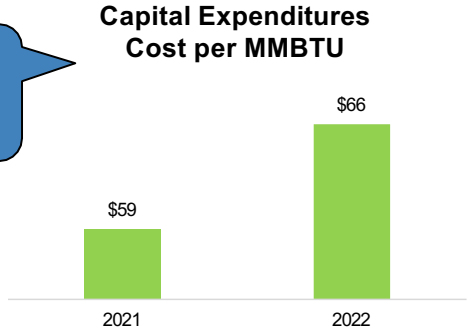
Why did Capital expenditures increase by 24% from 2021 to 2022…..

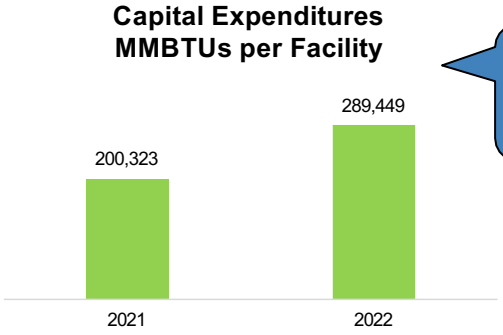




….when the number of facilities under construction went down by 23%?

Its because the cost of construction per MMBTU went up by 12%....





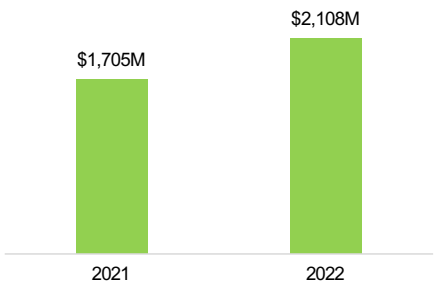
…. and the average # of MMBTUs per facility increased by 44%

Comparison between 2021 and 2022

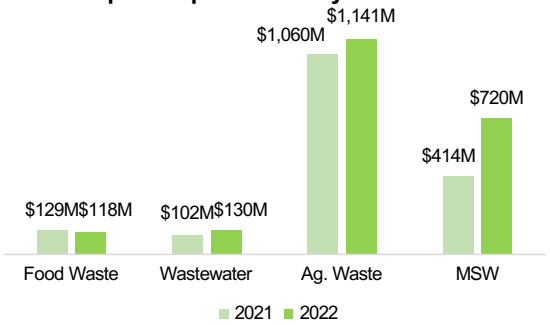
Capital expenditures increased across every feedstock except food waste

MSW saw the largest increase in capital expenditures (74%) primarily because the number of MSW facilities under construction increased by 71%. The capital expenditures on ag. waste facilities increased by 8% despite the number of ag. waste construction projects decreasing by 33%.

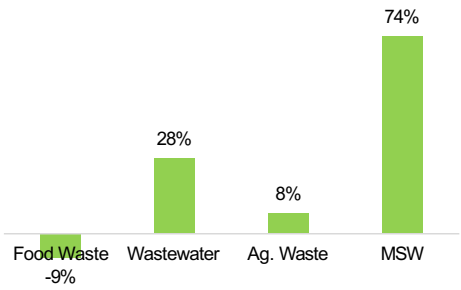
Capital Expenditures by Year



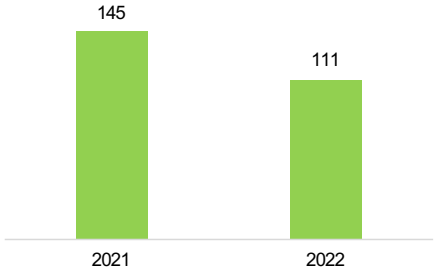
Capital Expenditures by Feedstock



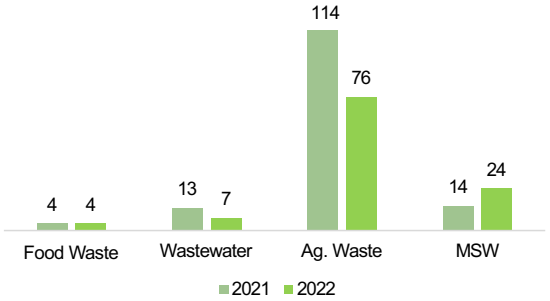
% Change in Capital Expenditures



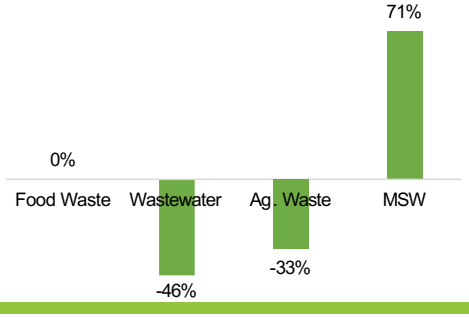
Number of Facilities in Construction



Number of Facilities by Feedstock in Construction



% Change in Number of Facilities in Construction

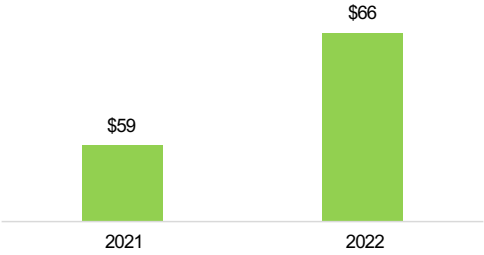


Comparison between 2021 and 2022

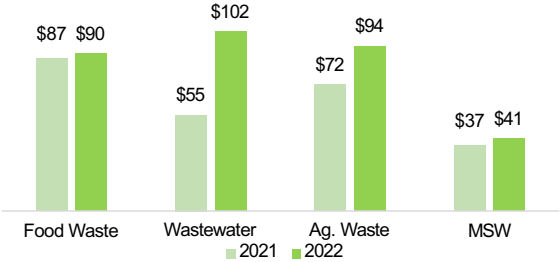
Drivers of capital expenditure increases

The increase in construction costs per MMBTU and the increased facility size were the primary drivers of increased capital expenditures. Wastewater saw the largest increase in cost per MMBTU (87%) and the average facility size increased by 44%, driven primarily by productivity increases in wastewater (28%) and ag. waste (24%).

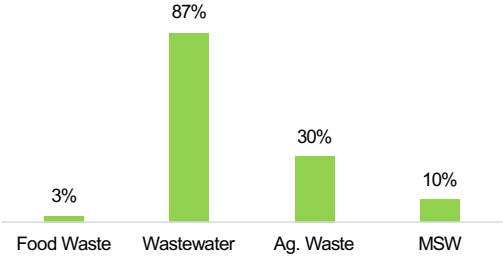
Cost per MMBTU by Year



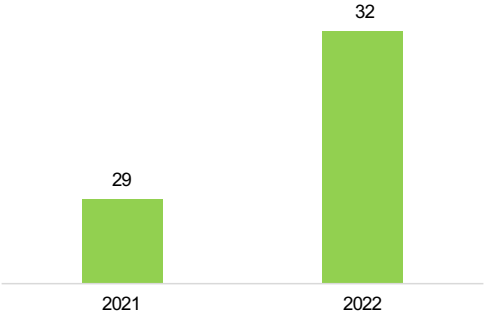
Cost per MMBTU by Feedstock



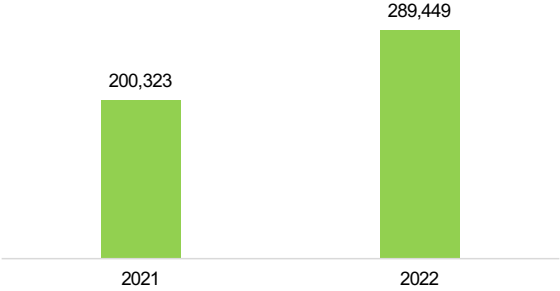
% Change in Cost per MMBTU



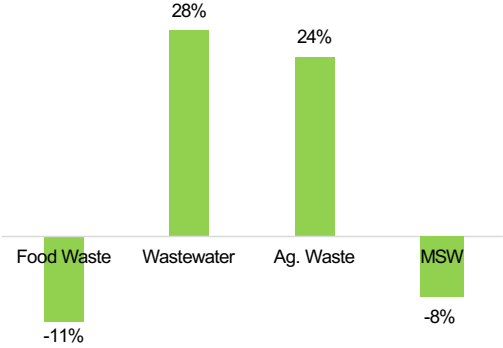
Millions of MMBTUs by Year



MMBTUs per Facility by Year



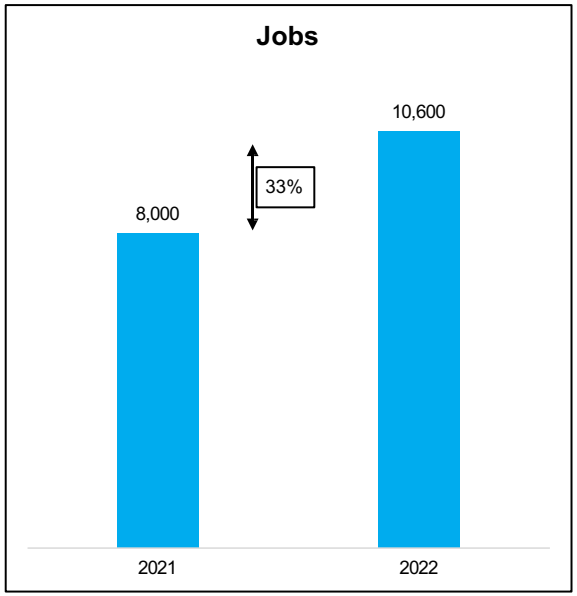
% Change in MMBTUs per Facility by Feedstock

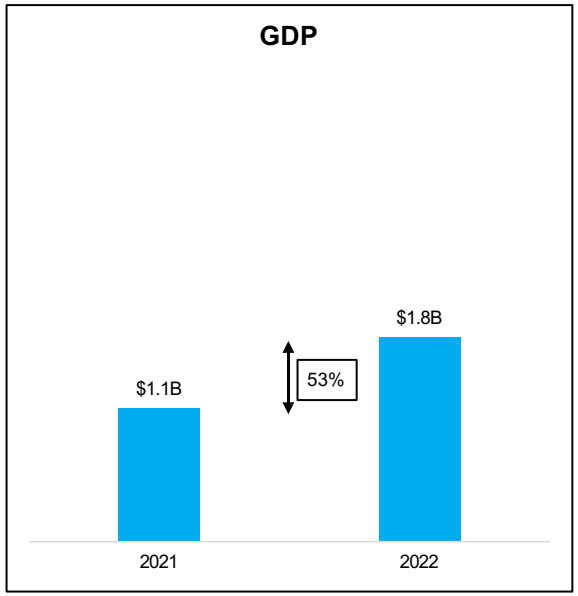


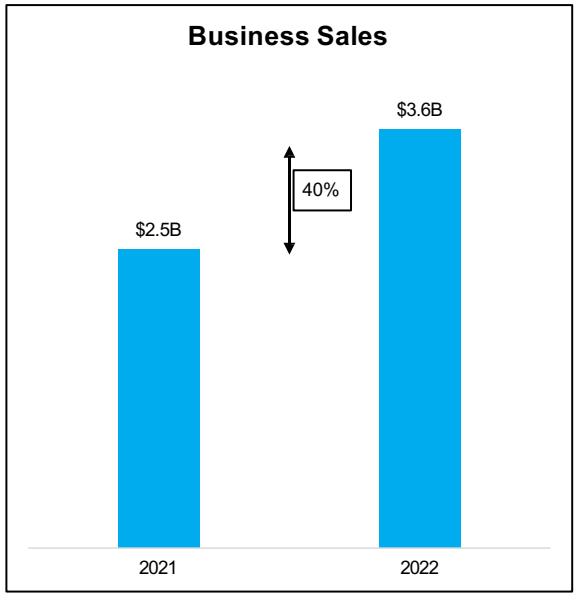
Comparison between 2021 and 2022

Economic impacts: operating facilities

The economic impacts associated with RNG facilities currently in operation increased by 33% for jobs, 56% for GDP, and 40% for business sales between 2021 and 2022. This increase is driven by changes in the number of operating facilities, MMBTUs produced per facility, changes in costs, and increased inflation.



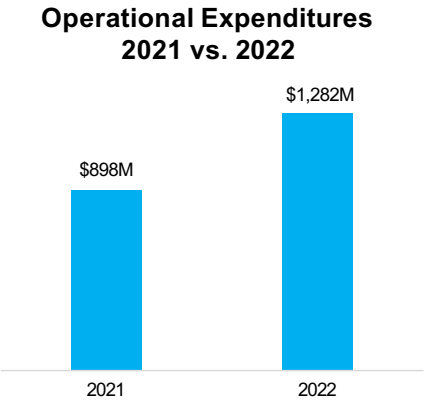


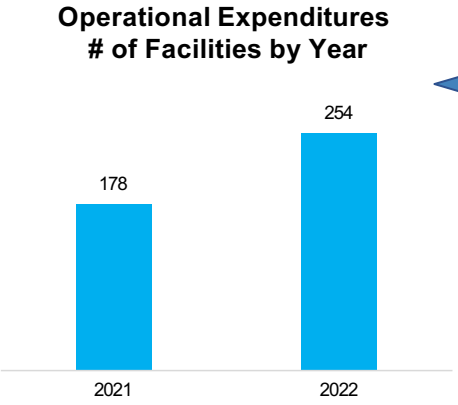


Comparison between 2021 and 2022

Capital expenditures by facility increased from 2021 to 2022

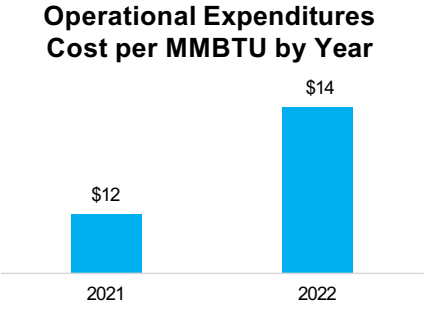
Operational expenditures increased by 43% from 2021 to 2022…..

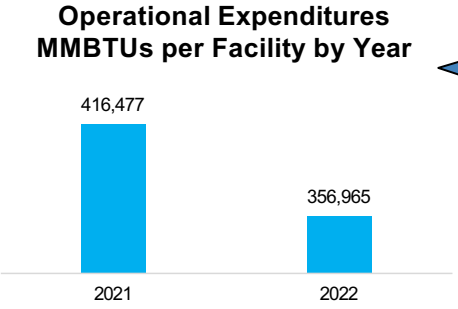




….primarily driven by the 43% increase in the # of operating facilities….

…..and because operational costs per MMBTU increased by 17%.....





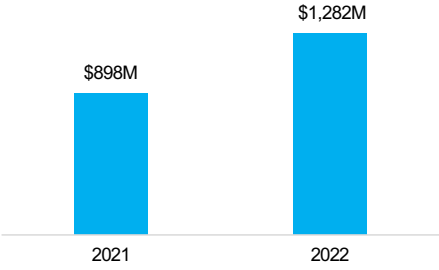
…. despite a 14% decrease in the average # of MMBTUs per facility

Comparison between 2021 and 2022

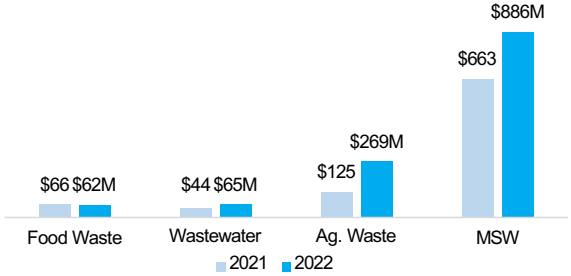
Operational expenditures increased across every feedstock except food waste

The number of RNG facilities in operation increased 43% from 2021 to 2022. Ag. waste saw the largest percent increase in capital expenditures (116%) primarily driven by an 89% increase in the number of facilities. MSW continued to have the highest operational costs (69% of all costs).

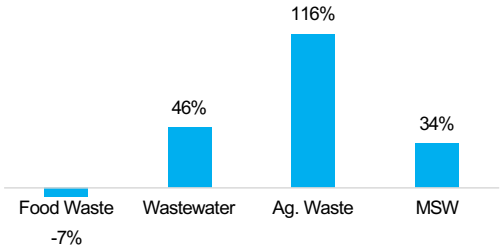
Operational Expenditures by Year



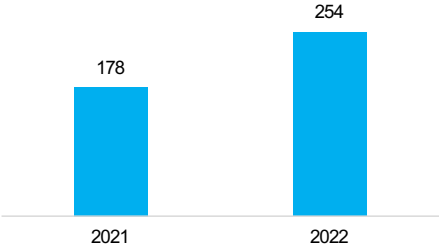
Operational Expenditures by Feedstock



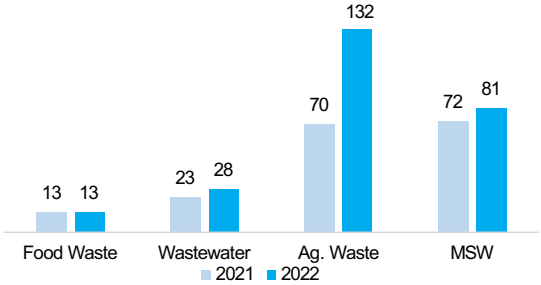
% Change in Operational Expenditures by Feedstock



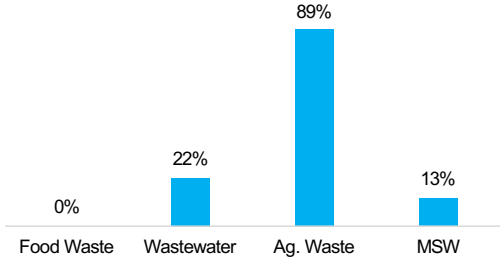
Number of Facilities in Operation



Number of Facilities by Feedstock in Operation



% Change in # of Facilities in Construction

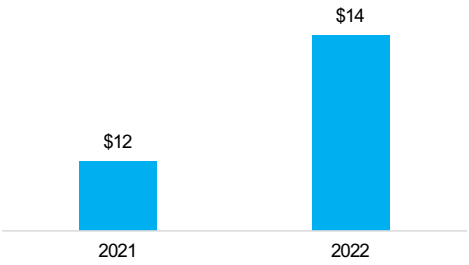


Comparison between 2021 and 2022

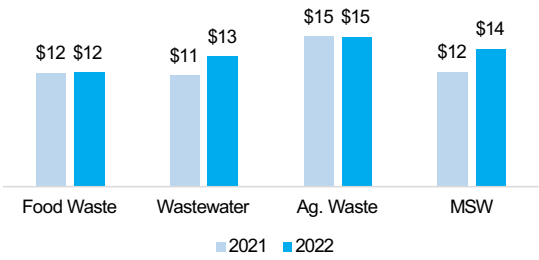
Drivers of operational expenditure increases

Operating costs per MMBTU increased by 17% from 2021 to 2022 driven by cost increases within wastewater (17%) and MSW (20%) feedstocks. The 22% increase in RNG MMBTUs produced resulted in higher operations costs despite a 14% drop in the average number of MMBTUs produced per facility. Ag. waste had the highest overall increase in MMBTUs produced (117%).

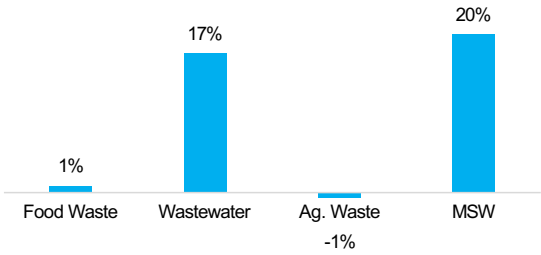
Cost per MMBTU by Year



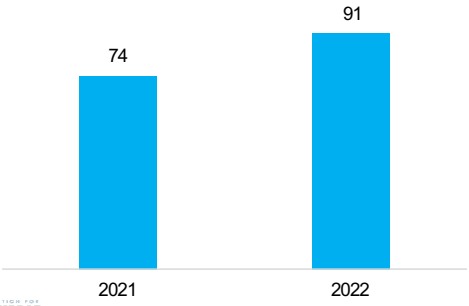
Cost per MMBTU by Feedstock



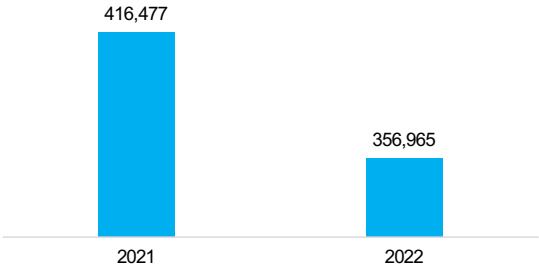
% Change in Cost per MMBTU



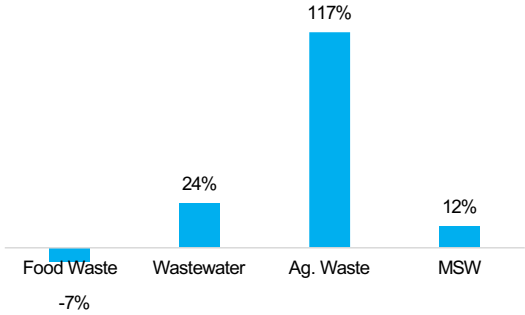
Millions of MMBTUs by Year



MMBTUs per Facility by Year



% Change in MMBTUs by Feedstock



Contents

This study sets out to analyze the current economic contribution of Renewable Natural Gas (RNG) to the US economy in 2022

This report is comprised of four sections:

1

RNG Overview

Introduces renewable natural gas (RNG)

2

RNG Value Chain

Overview of the RNG value chain from waste collection to final use

3

Expenditure Analysis

Calculates the spending associated with RNG 1) operations and 2) capital expenditures

4

Economic Impact

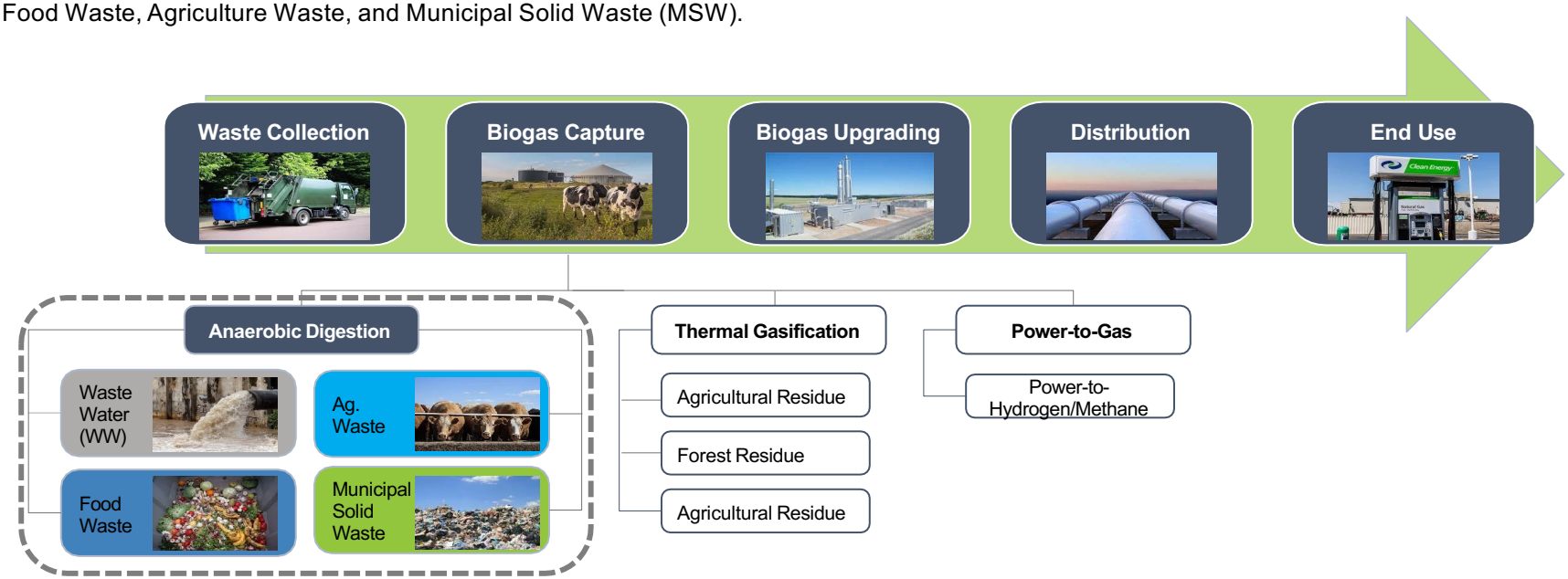
Estimates jobs, GDP, and sales associated with RNG 1) operations and 2) capital expenditures

This study answers the following questions:

1. What is RNG and how is it produced?
2. What are the stages within the RNG value chain?
3. What are the costs of RNG?
4. What impact does RNG have on the U.S. economy?

1 RNG Overview: RNG is a clean, affordable, and reliable waste-derived fuel that can be used for transportation fuel for vehicles, generation of electricity, and thermal heating applications

Renewable Natural Gas (RNG) is type of fuel that comes from a variety of waste sources. As that waste breaks down, biogas is captured through Anaerobic Digestion, Thermal Gasification, or Power-to-Gas technologies. The biogas is upgraded into biomethane after carbon dioxide, hydrogen sulfide, and other gases are removed. The biomethane is fully interchangeable with natural gas and can be used for local uses or injected into natural gas distribution systems. This report will cover the four feedstocks of Anaerobic Digestion, the most common RNG technology: Wastewater, Food Waste, Agriculture Waste, and Municipal Solid Waste (MSW).



1 RNG Overview: Because of its greenhouse gas (GHG) reducing potential, RNG is considered a low-carbon fuel under the federal Renewable Fuel Standard and state low-carbon fuel standards

All sectors of the U.S. economy will need to decarbonize dramatically to reach the 2050 GHG emissions targets set by a growing number of states, enabling new business opportunities for renewable natural gas. RNG produced from organic wastes leads to GHG reductions in two ways:

1. Displacing the use of diesel in vehicles

RNG can facilitate the displacement of life-cycle GHG emissions from fossil fuel use in vehicles[2]

RNG reduces **660** million gallons of diesel consumed by heavy duty vehicles[3]

Filling approximately **3 million** semi trucks or **7.3 million** transit buses

Reducing **14,792** million pounds of CO_2 emissions

2. Reducing emissions from waste management

Waste management accounts for one third of U.S. methane production and 3 percent of total U.S. GHG emissions.[4] Food waste is often sent to a landfill where methane is released or burned (e.g., turned into carbon dioxide) which enters the atmosphere. Other types of organic waste are placed in an open lagoon and release methane. To produce RNG, these gases are captured and cleaned rather than being released directly into the atmosphere

Waste Lagoon

Landfill Fire

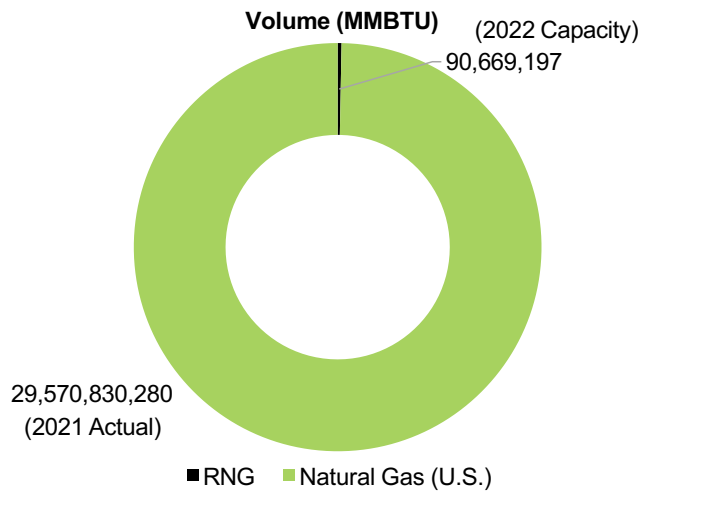
Anaerobic Digestors

[2]RNG's life-cycle net impact on GHG emissions also depends on the feedstock used, how much GHG would have otherwise been produced from fossil fuels, and how much methane escapes during RNG capture & upgrade
[3]Total RNG production capacity for 2022 converted from RNG in Ethanol Gallon Equivalents (EGE) to Diesel Gallon Equivalents (DGE) using conversions found at: https://nhcleancities.org/2017/04/can-compare-energy-content-alternative-fuels-gasoline-diesel/
[4]World Resources Institute, 2015

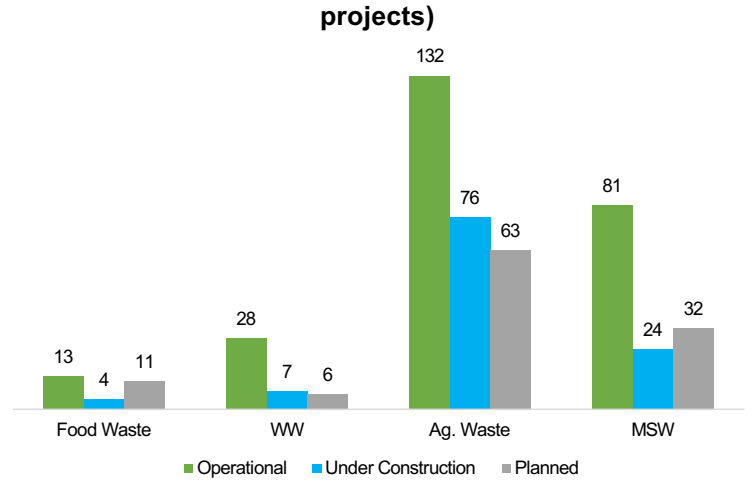
1 RNG Overview: With the total natural gas market at nearly 30 billion MMBTUs in 2021, current RNG production capacity represents an estimated 0.31% of the total market

Current renewable natural gas (RNG) production capacity in 2022 is nearly 91 trillion BTU's. When compared to total natural gas production in 2021, RNG production only accounts for 0.31% of the total market[5] and equates to over 1 billion gallons of ethanol gallon equivalent (EGE) or 710 million gallons of gasoline gallon equivalent (GGE). There are currently 254 operational RNG facilities and 223 facilities under construction or planned. The agriculture sector has the most projects currently under construction (76).[6]

Estimated U.S. Natural Gas Market (MMBTU)



Facility Status 2022

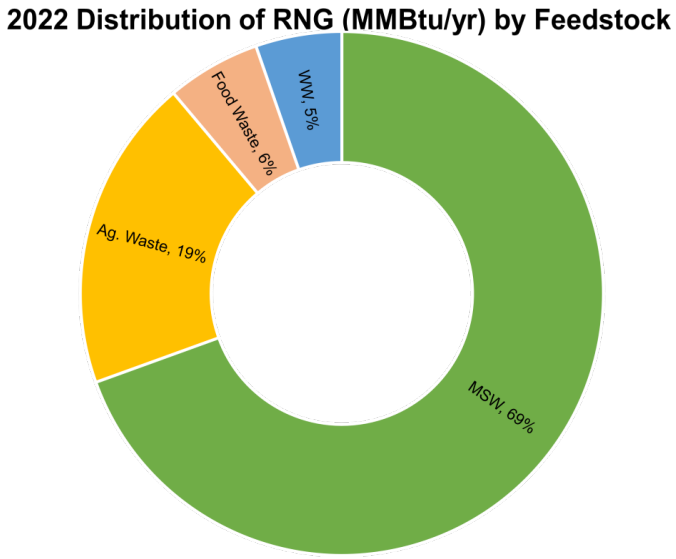


[5]Values for total RNG production and the U.S. natural gas market (U.S. Energy Information Administration (EIA)) are for the year 2021. This study assumes 100% of production capacity is utilized in 2022.
[6]2022 RNG capacity production volumes and capital expenditures data were provided by the RNG Coalition

1 RNG Overview: Sources of RNG by Feedstock

Current operating RNG facilities have the capacity to product nearly 91 trillion British thermal units (BTU) of biomethane in 2022. Of this, 69% is expected to come from landfills (MSW).[7]

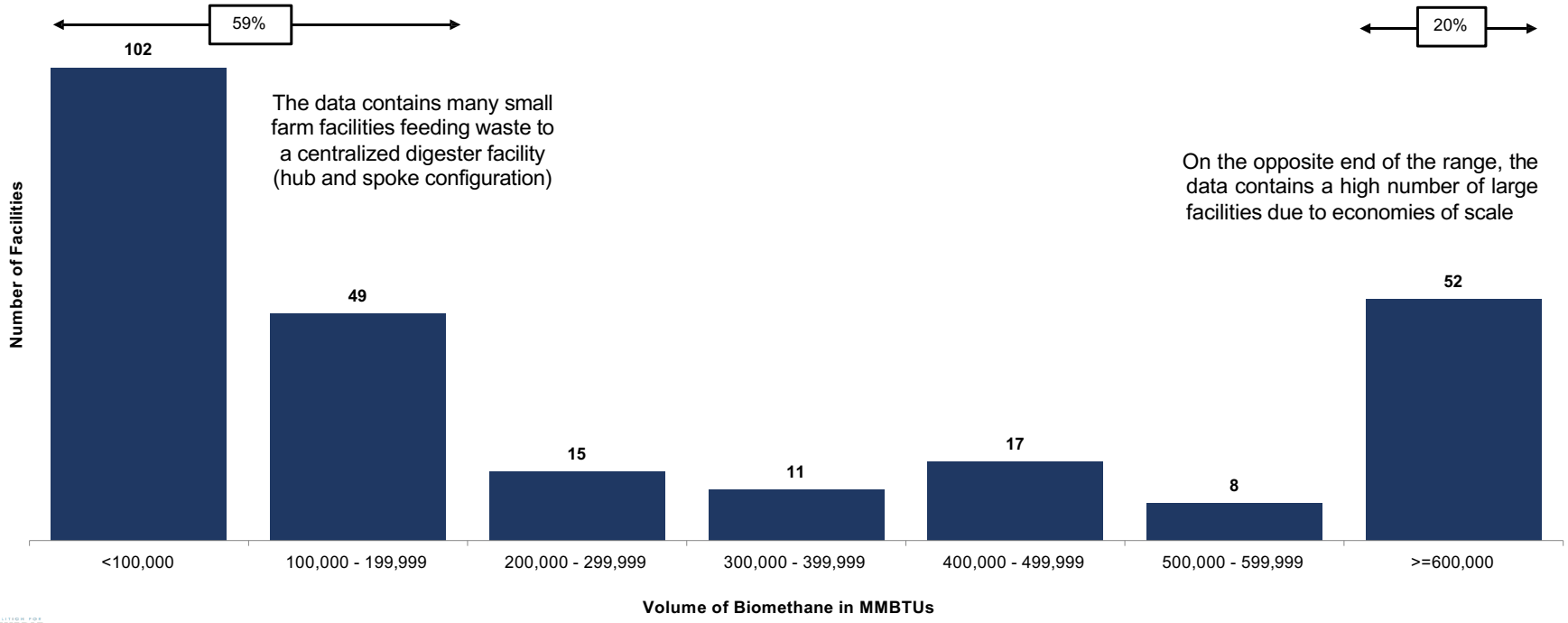
Distribution of Total Biomethane



[7]Data provided by the RNG Coalition and the Argonne National Laboratory (ANL)

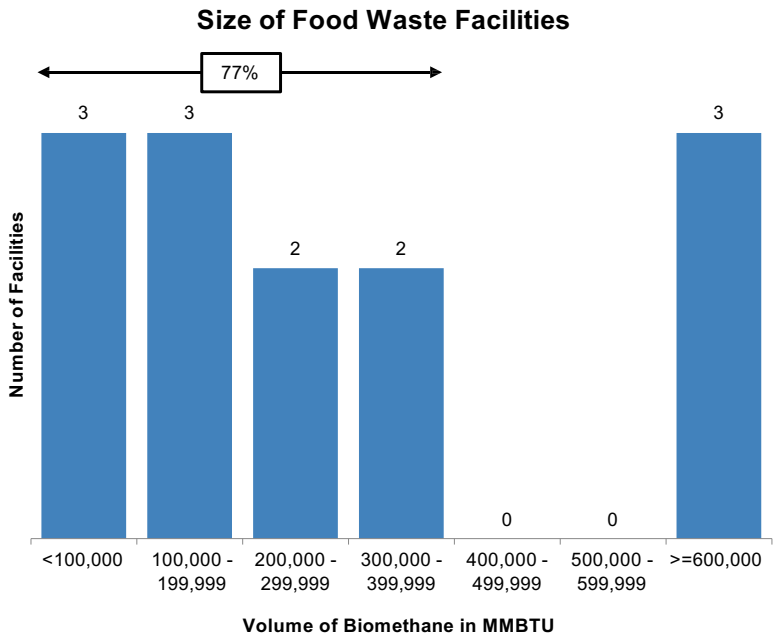
1 RNG Overview: There is a range of Operational RNG facility sizes by volume of MMBTUs

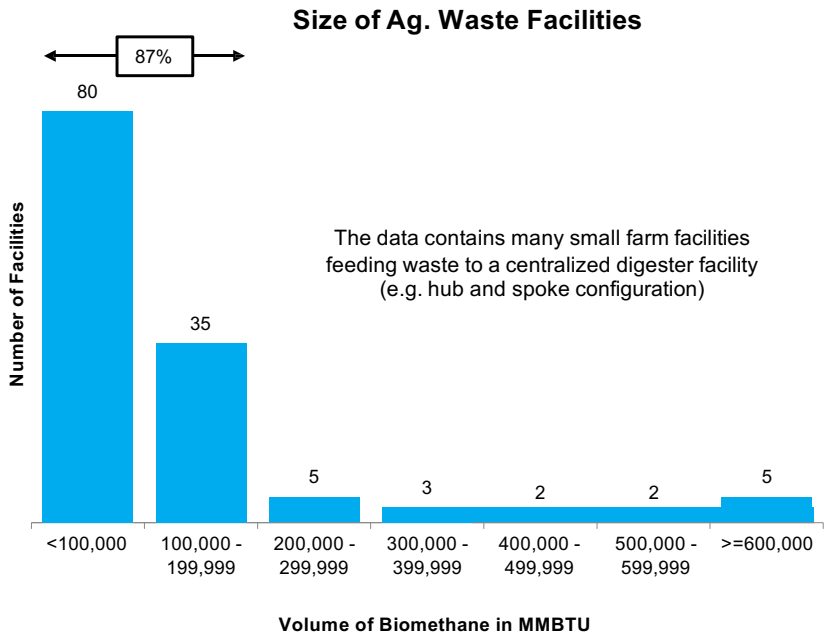
Presented below are the histograms for all operational RNG facilities grouped by range of biomethane production capacity (in MMBTUs). One hundred and two facilities produce less than 100,000 MMBTUs while 49 facilities produce between 100,000 and less than 200,000 MMBTUs (both ranges from primarily agriculture waste). Combined, these 151 facilities represent 59% of all operating RNG facilities. On the upper end of the spectrum, 52 facilities (primarily MSW) produce 600,000 or more MMBTUs of RNG (20%).



1 RNG Overview: There is a range of Operational RNG facility sizes by volume of MMBTUs for each feedstock

Presented below are the histograms for Food Waste and Agricultural Waste facilities grouped by range of biomethane production capacity (in MMBTUs). Seventy seven percent of all Food Waste facilities produce less than 400,000 MMBTUs of RNG while 87% of all Agricultural Waste facilities produce less than 200,000 MMBTUs of RNG (61%: <=100,000 MMBTUs and 27% between 100,000 and less than 200,000 MBTUs).

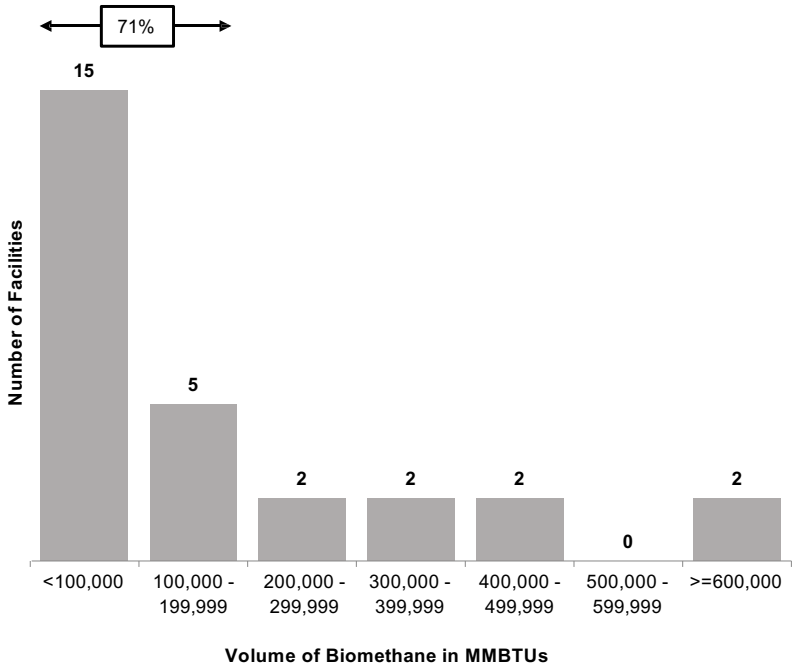




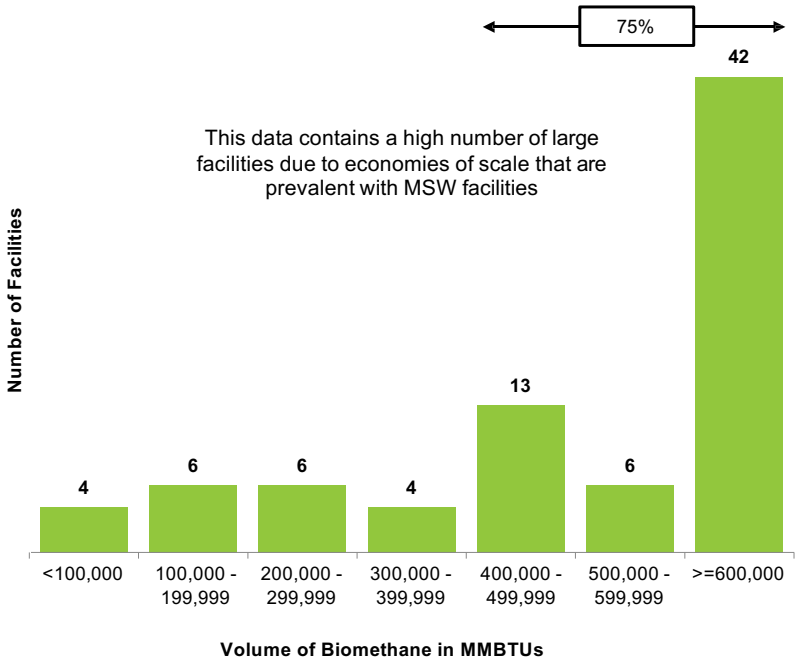
1 RNG Overview: There is a range of Operational RNG facility sizes by volume of MMBTUs for each feedstock

Presented below are the histograms for Wastewater and MSW facilities grouped by range of biomethane production capacity (in MMBTUs). For Wastewater, 71% of facilities produce less than 200,000 MMBTUs whereas 75% of MSW facilities produce more than or equal to 400,000 MMBTUs of RNG.

Size of Wastewater Facilities



Size of MSW Facilities



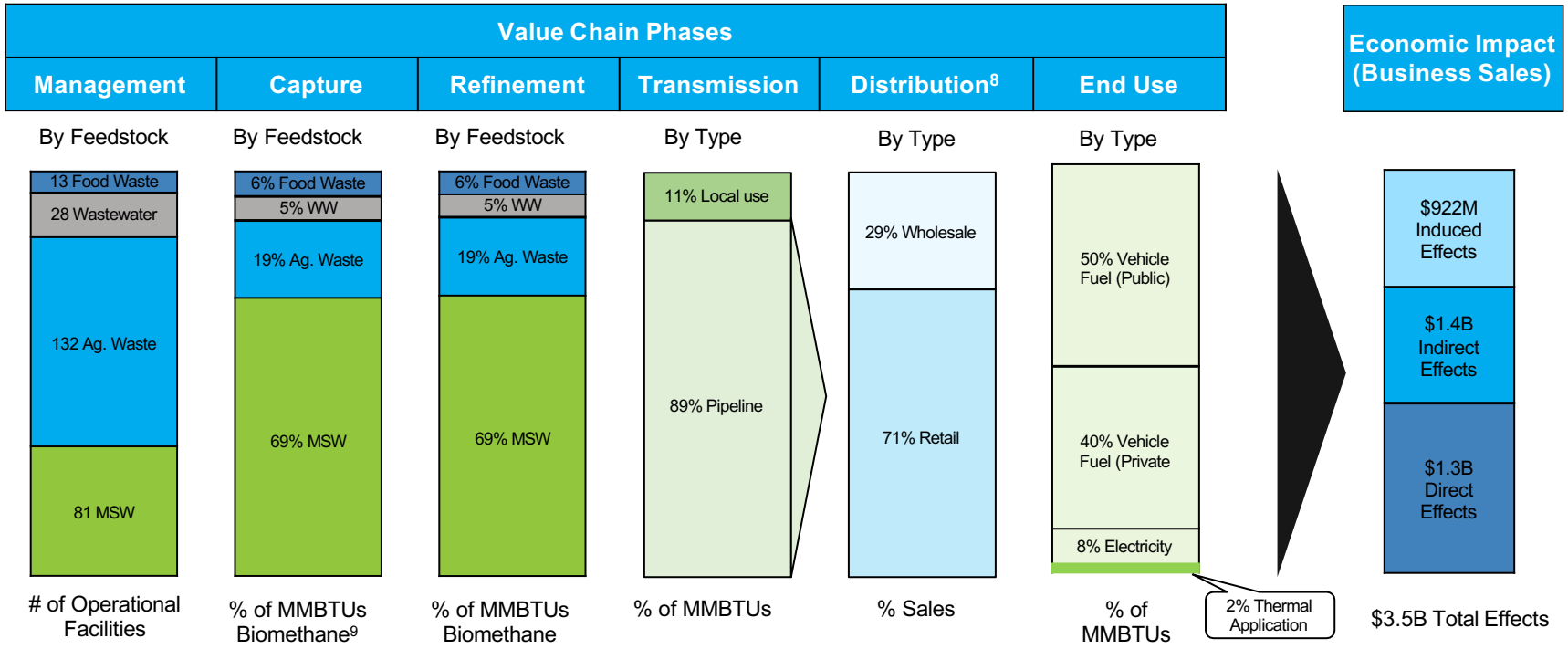
2 RNG Value Chain: The are 6 stages within the RNG value chain

Each stage of the value chain plays a role in the capture and upgrade of RNG ranging from management (waste collection) to distribution. A portion of RNG is transported via local pipeline for local vehicle usage while the remaining portion is injected into the natural gas pipeline system. The value chain is important to understanding the operation costs associated with RNG which is used to calculate its economic impact.

		Value Chain Phases					
Size	**Description**	**Management**	**Capture**	**Refinement**	**Transmission**	**Distribution**	**End Use**
Small Ops (aggregate waste to larger facility)	On/Off site anerobic digestion (hub & spoke)	Collection of waste	Anerobic digestion of waste (on-site or off-site)	Biogas is upgraded to biomethane by removing $C0_2$, H_2S, and other trace gasses	Use of local pipeline or injection of RNG into the Natural Gas pipeline network	Vehicle fuel is distributed to end users via local pipeline or through wholesale / retail channels.	Vehicle fuel, electricity generation, and thermal heating application
Large Ops (Onsite capture)	Onsite anerobic digestion (pipeline)		Anerobic digestion of waste (on-site)				

2 RNG Value Chain: Each stage becomes an input into the economic impact of RNG

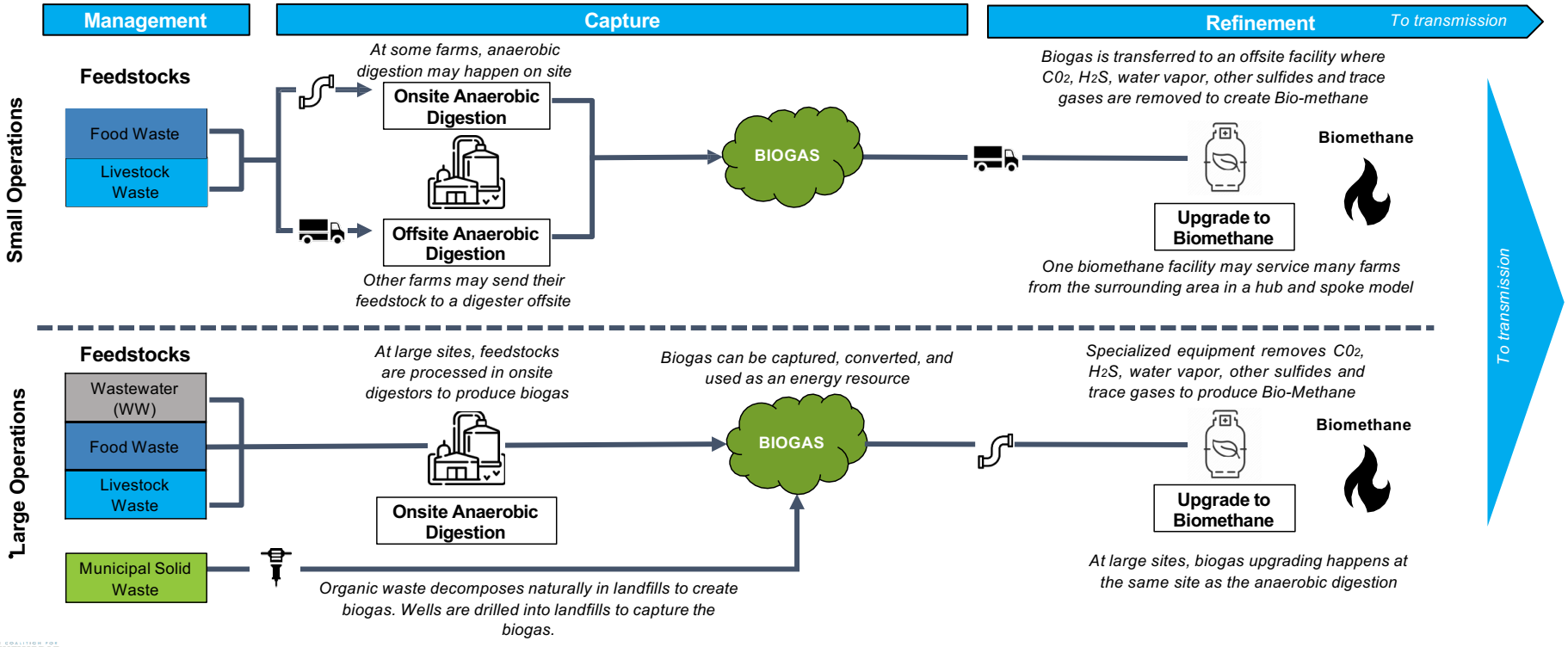
This diagram details the percentage of feedstock contribution associated with the first three phases of the value chain and how they ultimately feed into the economic impact of the RNG industry in 2022.



[8]Distribution types for vehicle fuel
[9]RNG Coalition data only included MMBtu volumes of Biomethane

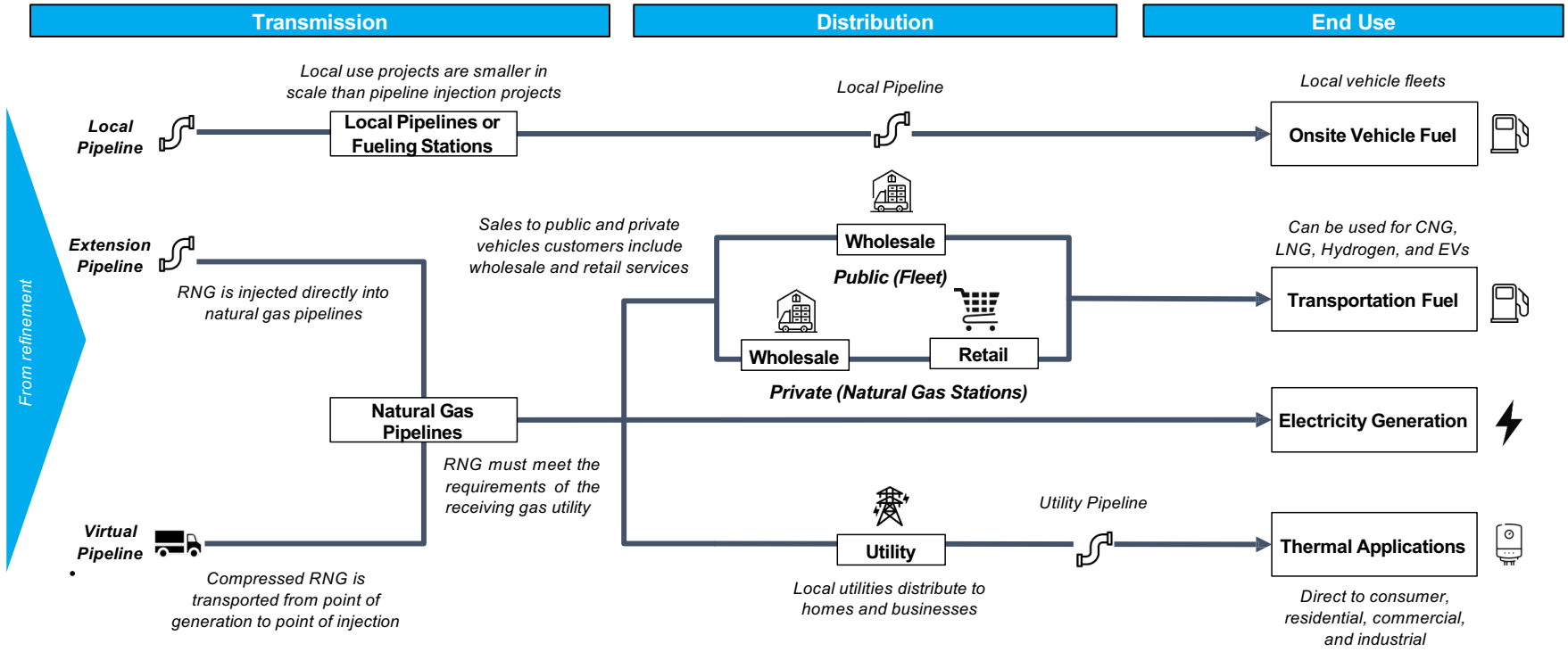
2 RNG Value Chain: This diagram illustrates the management, capture, and refinement phases of the Anaerobic Digestion value chain

There are generally two streams for the management, capture, and refinement phases of the value chain. Many small operations must capture and refine their biogas offsite, resulting in a hub and spoke model for upgrading, while many large operations can capture and refine biogas onsite.



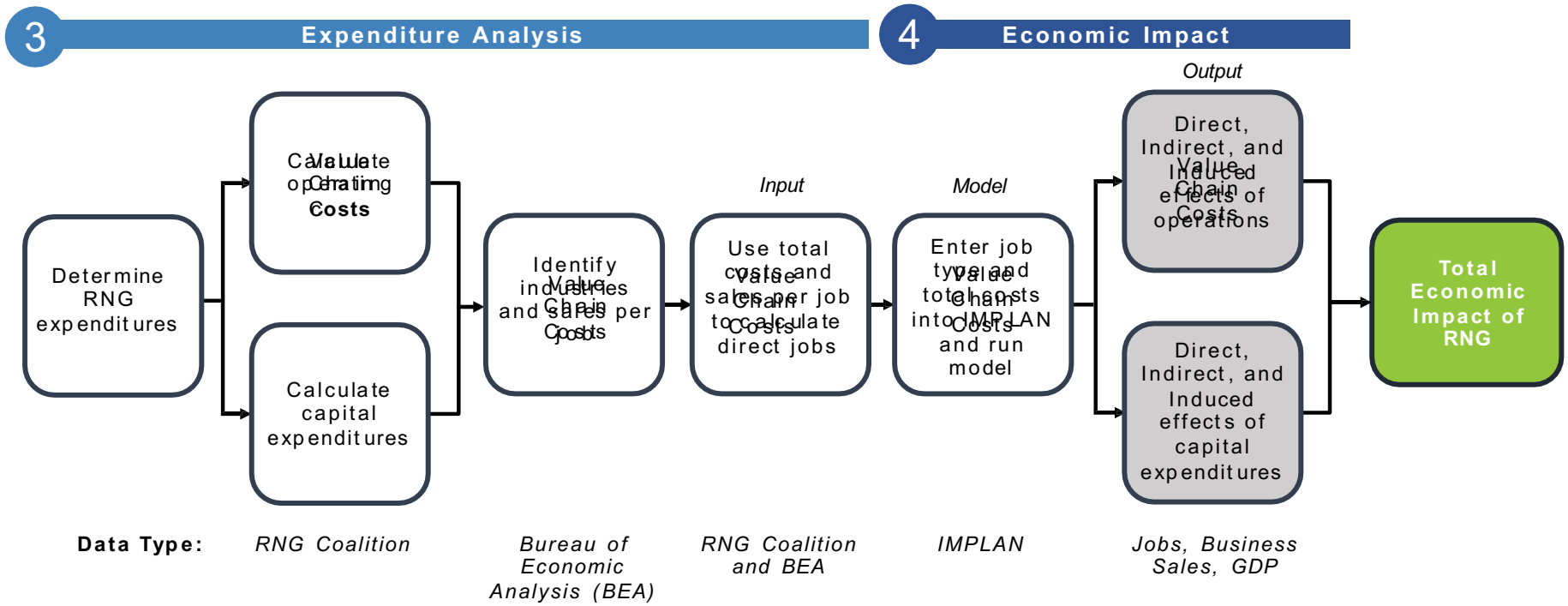
2 RNG Value Chain: This diagram illustrates the transmission, distribution, and end use phases of the Anaerobic Digestion value chain

All biomethane, whether produced onsite or at a centralized upgrading location, is transmitted through one of three ways:



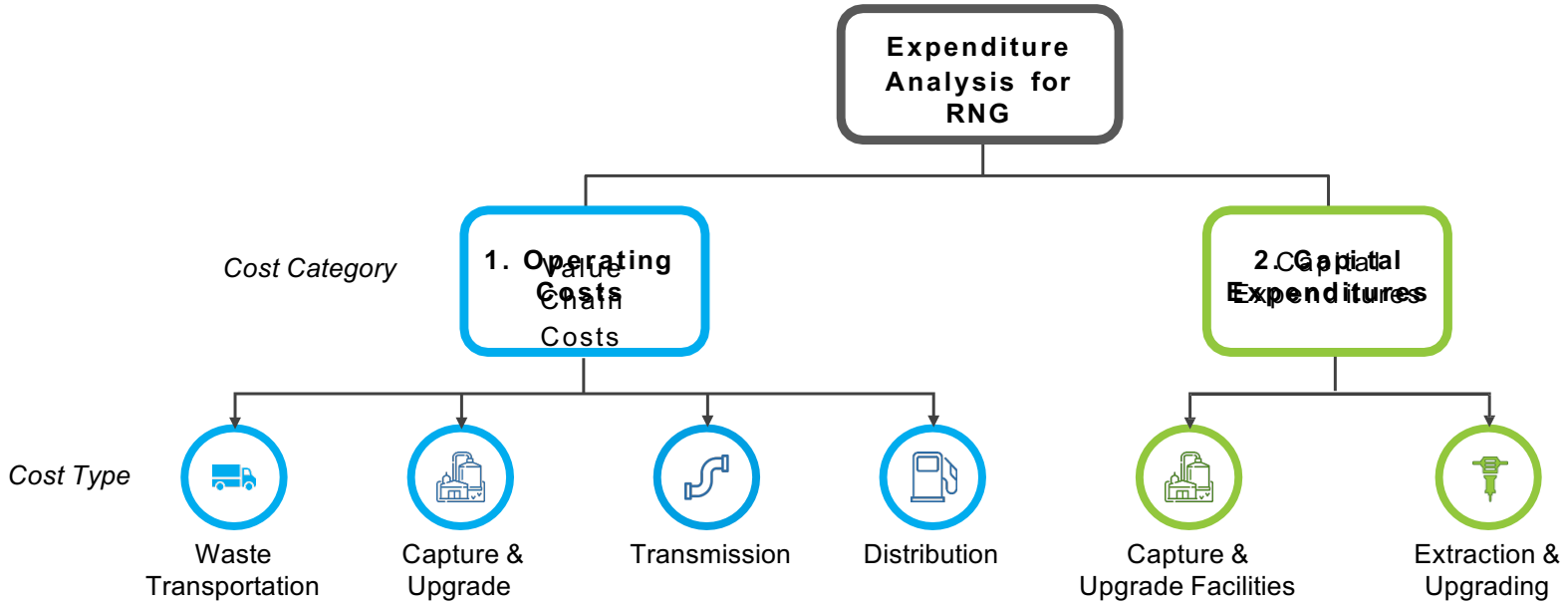
3 Expenditure Analysis: This study uses an input-output analysis model to analyze the economic impacts of RNG to the US economy in 2022

This study employed an input-output economic impact method of analysis since the primary focus is the economic impacts of RNG operations and capital expenditures on the U.S. economy. This analysis method is the most appropriate for this task. The diagram below illustrates the steps, outputs, and data types used to calculate the total current economic impact of RNG.



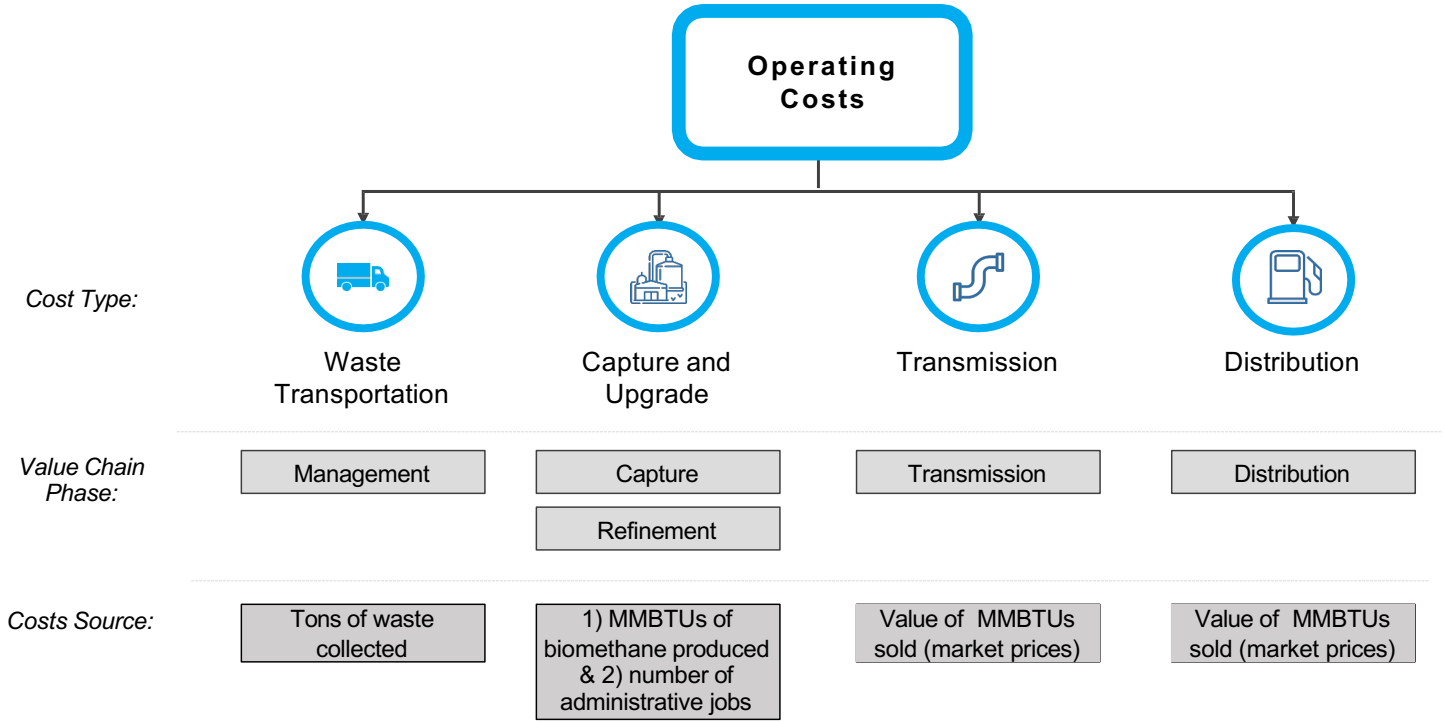
3 Expenditure Analysis: The inputs to the 2022 economic impact analysis are based on two cost categories: 1) operating costs and 2) capital expenditures

Operating costs refer to the ongoing expenses incurred from the normal day-to-day of running of the waste transportation, capture and upgrade, transmission, and distribution phases of the value chain. Capital expenditures refers to the construction costs for the extraction, capture, and upgrade of biogas into RNG. Each cost category is broken down further into cost types as depicted below:



3 Expenditure Analysis: Understanding the operating costs of RNG

Within operating costs, there are four types of costs mapped onto the five phases of the value chain depicted below. Sources of information to calculate costs for each cost type are also cited below.



3 Expenditure Analysis: Waste transportation costs - $23.3M

Waste collection is the initial step in producing RNG from Food Waste and Agricultural Waste feedstocks. Using data from the Argonne National Lab and the Coalition for Renewable Natural Gas, we determined how much waste was needed to produce the amount of biomethane generated by each feedstock facility. Estimates of transportation cost per ton were then used to determine the total transportation costs of moving food and agricultural waste from generation site to RNG facility. Wastewater and municipal solid waste were not included in these estimates because collection of these feedstocks would have occurred regardless of any biogas capture and upgrading.

Waste Transportation Costs

Feedstock	MMBTU	Tons of Waste per MMBTU[10]	Tons of Waste	Cost per Ton[11]	Transp. Costs
Food Waste	5.3T	0.48	2.5M tons	$1.69/ton	$4.3M
Ag. Waste	17.5T	0.66	11.6M Tons	$1.69/ton	$19.5M
Total	22.8T		14M Tons		$23.8M

[10]Based on feedstock weighted average from Argonne National Labs database.
[11]Bioenergy Supply in Ireland 2015 – 2035. Sustainable Energy Authority of Ireland.

3 Expenditure Analysis: Capture and upgrade costs for RNG consist of two sources: 1) upgrading biogas to biomethane (RNG) and 2) administrative costs

Upgrading biogas to biomethane is the second type of operational cost associated with the production of RNG. The process of estimating capture and upgrading and administrative costs are illustrated below.

RNG Capture & Upgrade

1. RNG Capture & Upgrading

- Identify ranges of average cost of biogas capture & upgrade per $/MMBTU
- Assign range of costs to specific levels of Biomethane production (in MMBTUs)
- Multiply the capture & upgrading cost per MMBTUs times the volume for each facility

2. Administrative Costs

- Identify and count the number of RNG Facilities
- Add one administrative job per facility
- Sum the number of administrative jobs for all RNG facilities

3 Expenditure Analysis: The average $/MMBTU cost of upgrading biogas to RNG ranges from $7 per MMBTU up to $23 per MMBTU

To calculate the capture and upgrading costs of biogas to biomethane for different levels of volume, Guidehouse used a variety of data sources indicating capture and upgrading costs ($/MMBTU) ranged from $7 per MMBTU up to $23 per MMBTU. These costs were then assigned to different levels of biogas and biomethane volumes based on information contained in the EPA report. Converting the units of SCF per minute into annual MMBTUs of biomethane, Guidehouse created a RNG Cost/Volume matrix to reflect the average costs associated with different volumes of biogas capture and biomethane generation for each facility.

Averaging the ranges of $/MMBTU from the reports resulted in an average cost range of $7.44 to $23.60

Sources

RNG Cost/Volume Matrix			
Biogas Capture	Upgrade to Biomethane	Costs ($/MMBTU)	Production Costs
SCF/Min	MMBTU/Year[12]	Average	Average
50	13,600	$23.60	$0.321M
100	27,200	$17.77	$0.483M
200	54,400	$12.56	$0.683M
300	81,599	$12.56	$1.025M
475	129,199	$10.92	$1.411M
650	176,799	$9.29	$1.642M
1,125	305,998	$7.65	$2.342M
1,600	435,197	$7.44	$3.239M
2,300	625,595	$7.44	$4.656M

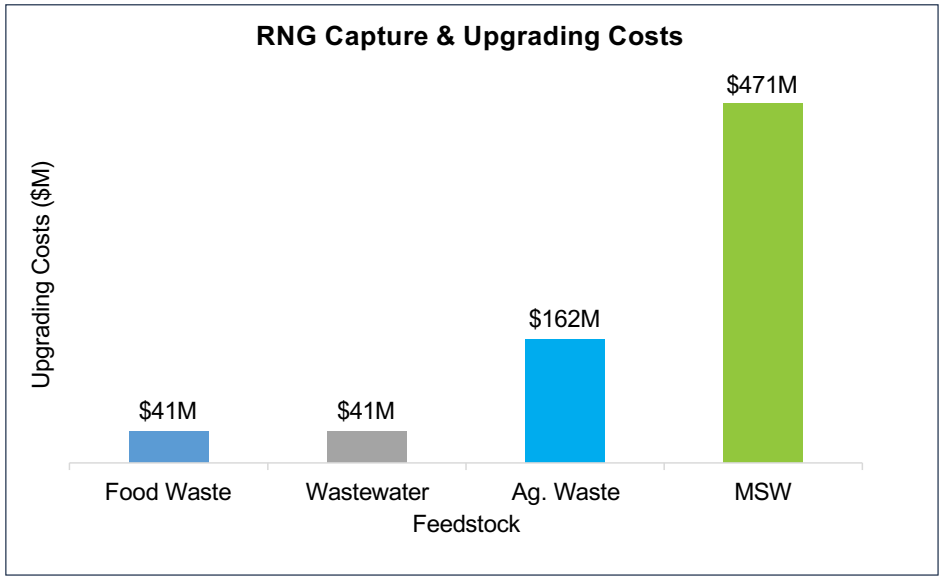
[12]Guidehouse used the Argonne National Lab Methodology to convert SCFM to MMBTU/Year: SCFD *.001 * 365 *.9 = MMBTU (Assumes 1,000 BTU/SCFD, 90% run time, 365 days)

3 Expenditure Analysis: Total capture and upgrade costs are estimated to be $715M in 2022

Guidehouse used the RNG Cost/Volume Matrix to estimate capture and upgrading costs by multiplying the MMBTUs produced times the $ per MMBTU for each facility and then aggregated across all feedstock types.[13] These values represent the costs of capturing the biogas and upgrading it into biomethane.

Total Cost of RNG Upgrading			
Feedstock(s)	**Volume (MMBTU/Year)**	**$ per MMBTU**	**Upgrading Costs**
Food Waste	5,267,000	$7.44 to $23.60	$41M
Wastewater	4,830,000		$41M
Ag. Waste	17,562,000		$162M
Municipal Solid Waste	63,003,000		$471M
Total	90,669,000		$715M

Municipal solid waste has the largest volume of RNG and therefore has the highest associated costs of $471 million. The total cost for upgrading RNG across all four feedstocks is $715 million.



[13]RNG costs were calculated using the sources outlined on slide 23. Volume amounts were provided by the RNG Coalition.

3 Expenditure Analysis: Administrative costs for RNG capture and upgrade are estimated to be $20.2M in 2022

The second cost component for capture and upgrade is administrative jobs. These jobs include overseeing financial transactions, bookkeeping, transactions, and other support services. To account for these activities, Guidehouse estimated 1 administrative job per operating facility based on guidance from RNG Coalition. Assuming an average income of $79k per admin job (U.S. Bureau of Economic Analysis) Guidehouse estimated the total administrative costs for each feedstock.

Total Administrative Costs					
Feedstock(s)	**Number of Operational Facilities**	**Admin Jobs per Facility**	**Number of Admin Jobs**	**Cost per Job[14]**	**Total Admin Costs**
Food waste	13	1	13	$79,609	$1.0M
Wastewater	28	1	28	$79,609	$2.2M
Ag. Waste	132	1	132	$79,609	$10.5M
Municipal Solid Waste	81	1	81	$79,609	$6.4M
Total	254		254	$79,609	$20.2M

[14] Average incomewage for office and administrative support jobs (BEA)

3 Expenditure Analysis: Adding upgrading costs and administrative costs together, the total cost for RNG capture and upgrade for all four feedstocks is estimated to be $735M in 2022

Costs associated with biogas capture, upgrade to biomethane (RNG), and administrative costs are combined to reflect the total RNG Capture and Upgrade Costs grouped by type of feedstock.

RNG Capture and Upgrade Costs

Input		Capture and Upgrade Costs				Total Cost
Feedstock(s)	Volume (MMBTU/Year)	1 Biogas Upgrading Costs		2 Total Admin Costs		Total Cost of Capture and Upgrade
Food Waste	5,267,000	$41M	+	$1.0M	=	$42M
Wastewater	4,830,000	$41M	+	$2.2M	=	$43M
Ag. Waste	17,562,000	$162M	+	$10.5M	=	$173M
Municipal Solid Waste	63,003,000	$471M	+	$6.4M	=	$478M
Total	90,669,000	$715M	+	$20.2M	=	$735M

3 Expenditure Analysis: Estimated cost of RNG transmission is $464M

Transmission is the third type of cost type in generating RNG. Of the 91 trillion BTUs of RNG production capacity in 2022, 81 trillion BTUs (89%) is estimated to be injected into the natural gas pipeline transmission system. Ninety percent of the RNG injected into the system is used for transportation fuel. Natural gas pricing information for each of the final uses was based on data from the U.S. Energy Information Administration (EIA). These prices and their associated volumes (in units of 1,000 SCF) were used to estimate total transmission sales.

Transmission

Final Use	MMBTUs[15]	% of Total	Volume (1,000 SCF)	Natural Gas Price	Sales
Vehicle (Public)	40,225,599	50%	38,790,356	$6.01	$233M
Vehicle (Private)	32,462,764	40%	31,304,498	$6.01	$188M
Electricity	6,461,188	8%	6,230,654	$4.67	$29M
Thermal	1,615,297	2%	1,557,663	$8.98	$14M
Total	80,764,849	100%	77,883,171		$464M

Definitions

Vehicles (Public) Government Agency Fleets

Vehicles (Private) Retail Natural Gas Stations

[15] Adjusted for only pipeline volume.

3 Expenditure Analysis: The total cost of distribution (wholesale and retail) for RNG was $58.2M

Distribution is the fourth type of cost in generating RNG. Of the four final uses, sales to public and private vehicles customers include wholesale and retail services. In addition to the transmission sales, wholesale (4%) and retail (22%) markup percentages were applied to account for distribution services provided. Wholesale services cost an additional $16.9M and retail services cost an additional $41.3M to distribute RNG to final users (e.g., public fleets and private natural gas retail stations).

Distribution

Final Use	Sales	Wholesale margin	Wholesale Sales	Retail Margin	Retail Sales	Total Sales
Vehicles (Public)	$233M	4%	$9.3M			$9.3M
Vehicles (Private)	$188M	4%	$7.5M	22%	$41.3M	$48.9M
Total	$421M		$16.9M		$41.3M	$58.2M

Definitions

Retail Margin The margin (e.g. mark-up) added to T&D sales to reflect associated retail costs

Wholesale Margin The margin (e.g. mark-up) added to T&D sales to reflect associated wholesale costs

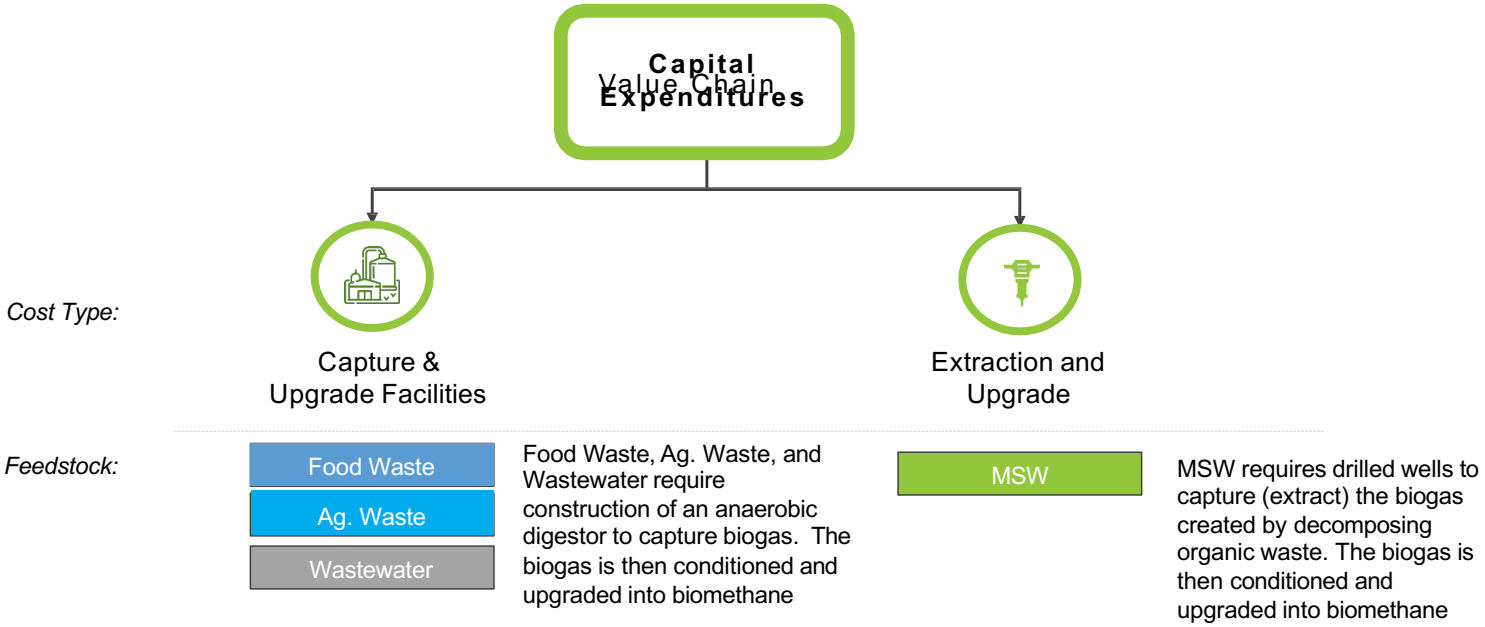
3 Expenditure Analysis: RNG operations costs are estimated to support 2,105 direct jobs in 2022

The total costs from the four major cost categories of the value chain were used to estimate the direct number of jobs for RNG production. Total costs are divided by the industry productivity ratios (e.g., sales per job) provided by the BEA. The calculations below illustrate how each of the 4 cost categories are used to estimate direct jobs by industry.

	Direct Effects		Industry Unit Relationships (sales per job)		Direct Jobs	Industry
Waste Transportation	$24M (Transportation)	÷	$257,000 / job	=	93	*Waste management*
Capture and Upgrade	$715M (Capture & Upgrade)	÷	$697,000 / job	=	1,026	*Misc. Chemical Product Mfg*
	$20M (Admin)	÷	$79,600/ job	=	254	*Office Administrative Services*
Transmission	$464M (Transmission)	÷	$1,258,000 / job	=	369	*Natural Gas Distribution*
	$17M (Wholesale)	÷	$1,561,000 / job	=	11	*Wholesale – Petroleum*
Distribution	$41M (Retail)	÷	$157,000 / job	=	263	*Retail – Gasoline Stores*
	Total: $1.3B			**Total Direct Jobs**	**2,015**	

3 Expenditure Analysis: Capital Expenditures associated with facility construction

The second cost category for producing RNG is capital expenditures. There are two types of capital expenditures: 1) Construction of Capture and Upgrade facilities and 2) Construction of Extraction and Upgrade facilities. These costs vary depending on the type of feedstock.



3 Expenditure Analysis: Across all feedstock types, the total cost of capital expenditures is estimated to be $2.1B

For food waste, agricultural waste, and wastewater, capturing and converting biogas into biomethane requires a digester and upgrading facilities. For municipal solid waste, the landfill acts as a digester and pipes are drilled into the ground to extract the biogas that naturally is generated. Costs per MMBTU and amount of MMBTUs expected to be produced were used to estimate construction costs for facilities without an original estimate.

Construction of Capture and Upgrade Facilities

Extraction and Upgrading

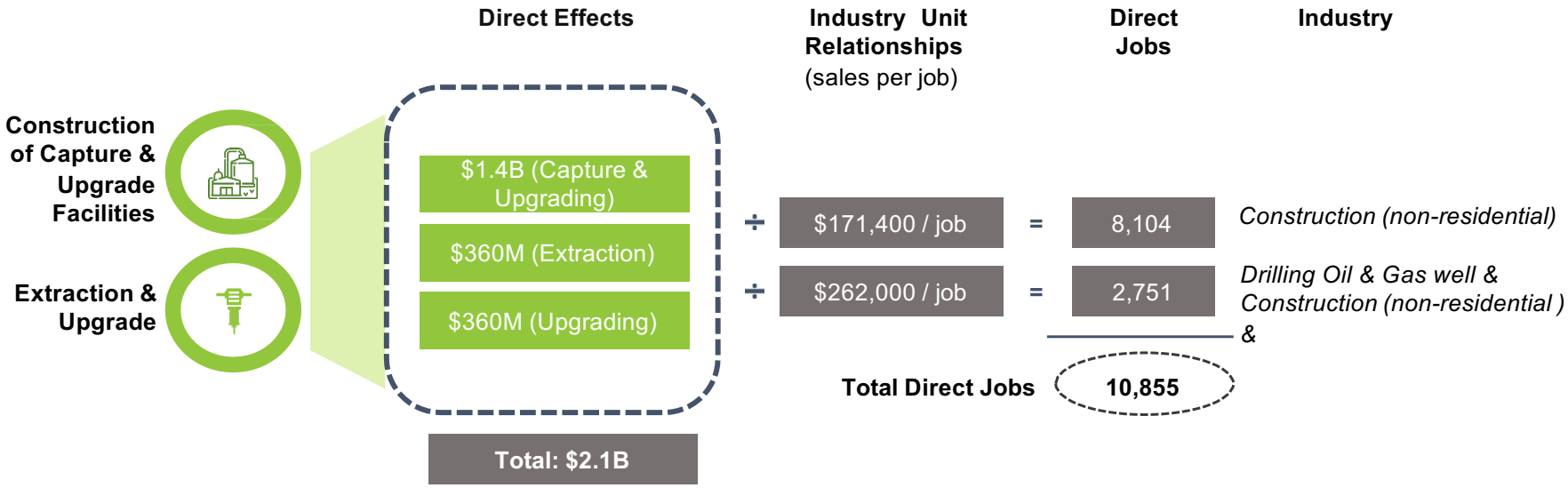
Feedstock	Expenditure Type	Expenditure ($)
Food Waste	Capture (Digester) and Upgrade	$118M
Agricultural Waste	Capture (Digester) and Upgrade	$1.1BM
Wastewater	Capture (Digester) and Upgrade	$130M
Municipal Solid Waste	Extraction and Upgrade	$720M
Total		$2.1B

Definitions

Capture and Upgrade	The cost of capture via anaerobic digester and biomethane upgrading
Extraction and Upgrade	The cost of capture via wells and biomethane upgrading

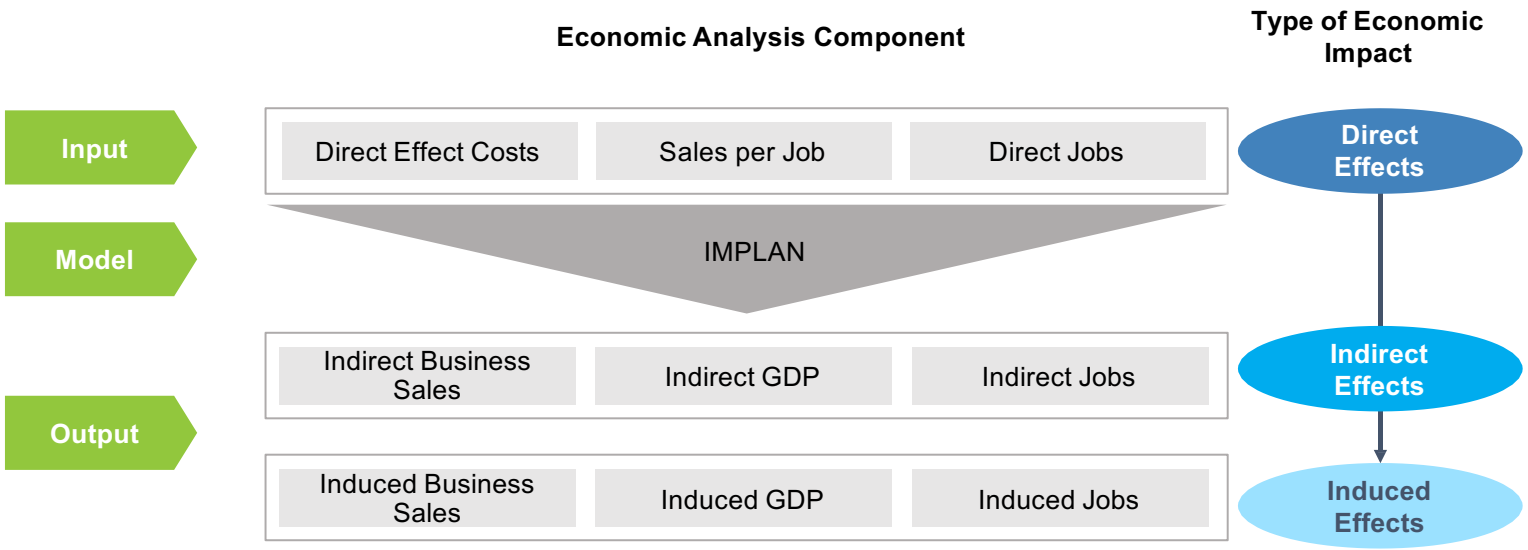
3 Expenditure Analysis: Based on RNG capital expenditure estimates, we estimate 10,855 direct jobs will be created from construction of RNG facilities during 2022

Total capital expenditures across all feedstocks are estimated to cost over $1.03B during 2022. These estimates were derived by dividing the construction costs by industry productivity ratios (e.g., sales per job) provided by the BEA (within IMPLAN). The calculations below illustrate how construction costs are used to estimate the 10,855 direct job counts by industry.



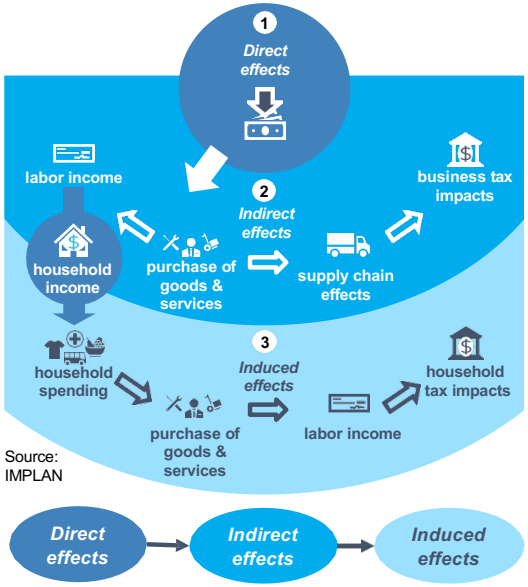
4 Economic Impact: The modeling tool IMPLAN calculates direct, indirect, and induced effects of RNG

The expenditures analysis produced three values for the operating costs and the capital expenditures of RNG – RNG Business Costs, Average Sales per Job, and the Number of Direct Jobs. This information is used as inputs in the economic modeling tool IMPLAN to calculate indirect and induced effects. This modeling indicates how much additional economic activity is supported by supplier purchases (indirect) and employee spending (induced) beyond the initial RNG capture and upgrade.



4 Economic Impact: Economic impact analysis allows us to understand the direct, indirect, and induced effects of RNG on the economy

The IMPLAN Input-output model estimates how money flows through the economy based on supply chain relationships; the effects are categorized into direct, indirect, and induced impacts. This analysis uses three types of metrics to reflect changes in the U.S. economy referenced in this report; business sales, Gross Domestic Product (GDP), and jobs.



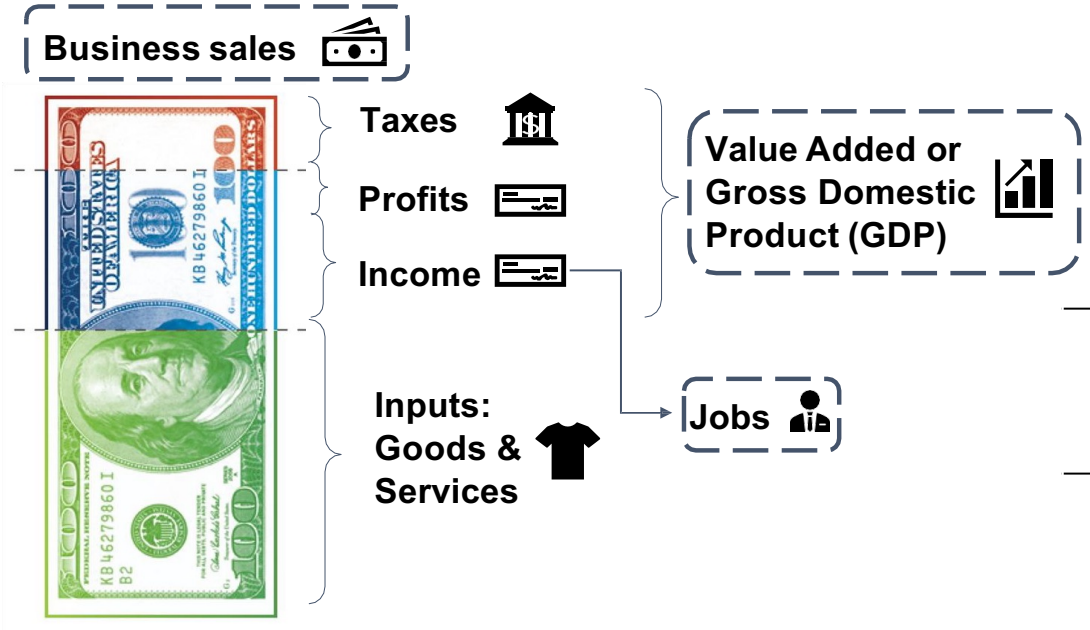
Source: IMPLAN

Type of impact	RNG Example
Direct Effects resulting from direct spending	Spending within the RNG value chain
Indirect Effects resulting from industries purchasing from each other	Spending on materials, components, and services
Induced Effects resulting from household spending of labor income	Spending on housing, healthcare, transportation, food, retail and entertainment by workers

Metrics used in this report

Business Sales	Sales of goods and services across the supply chain.
Gross Domestic Product (GDP)	The sum of the value added or 'premium' created from each stage of the supply chain
Jobs	The number of jobs created from the supply chain activity stimulated through expenditure

4 Economic Impact: Economic impact measures reflect changes in the economy but are subsets of one another, meaning that they should not be added together



Taxes
Profits
\+ Income

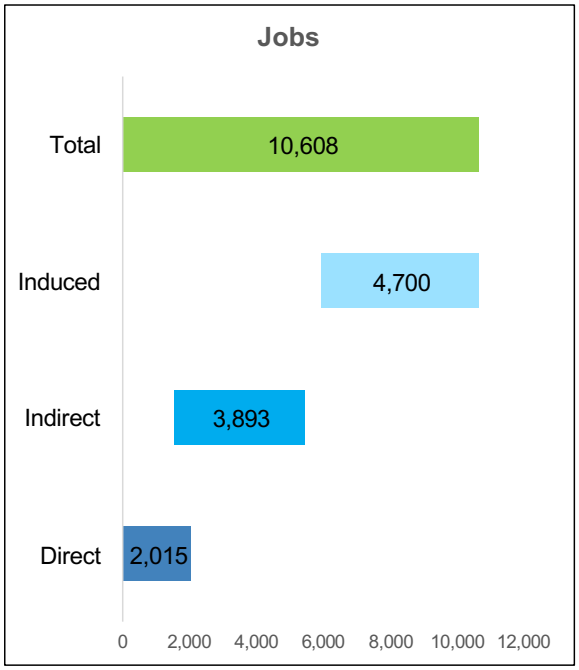
= Value Added (GDP)

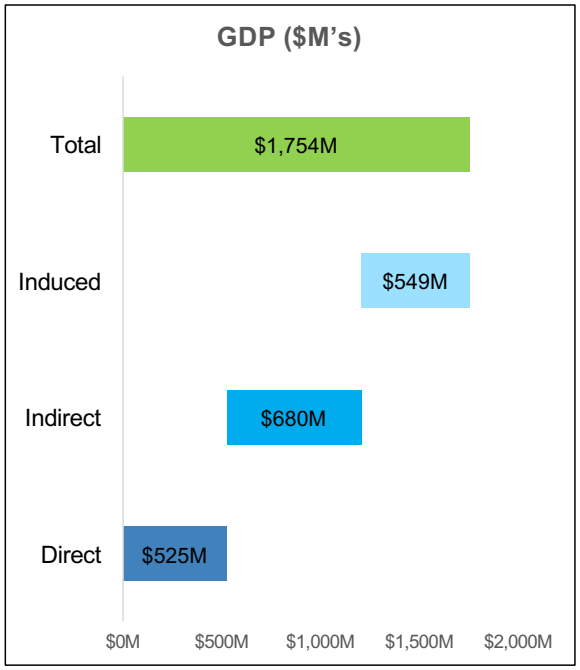
\+ Inputs

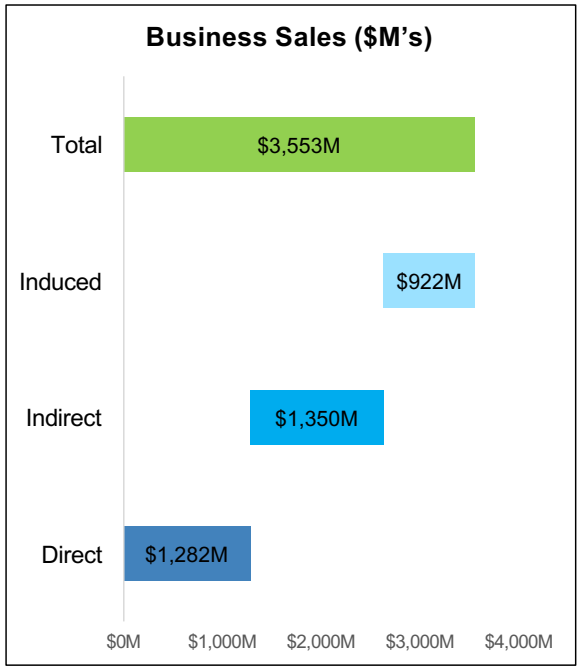
= Business Sales

4 Economic Impact: RNG operations are estimated to support a total of 10,600 jobs, generate a total of $1.8B in GDP, and result in over $3.5B in business sales in 2022

Based on the spending for RNG operations, the direct, indirect, and induced economic impacts are presented below in terms of jobs, GDP, and Business Sales. Over 2,015 direct jobs were attributed to activities within the RNG value chain with a total of 10,600 jobs. RNG supported a total of $1.8B in GDP and over $3.5B in business sales.

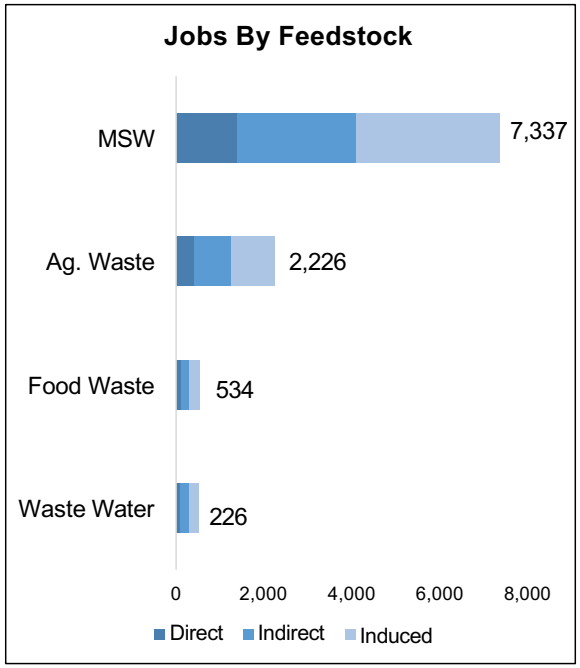


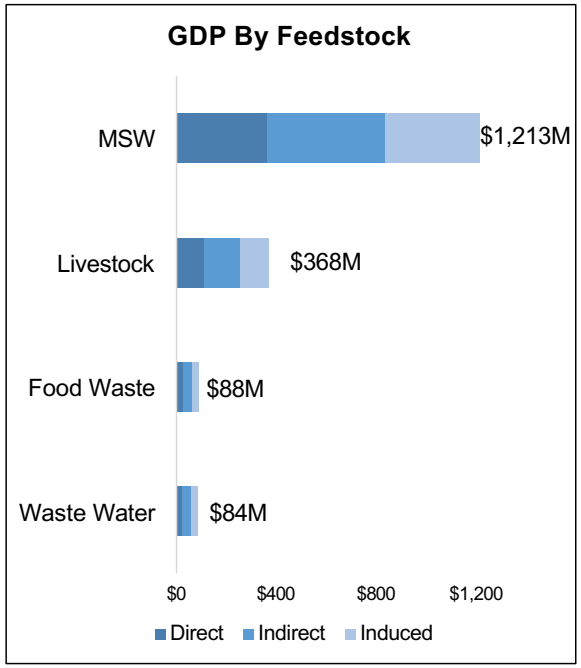


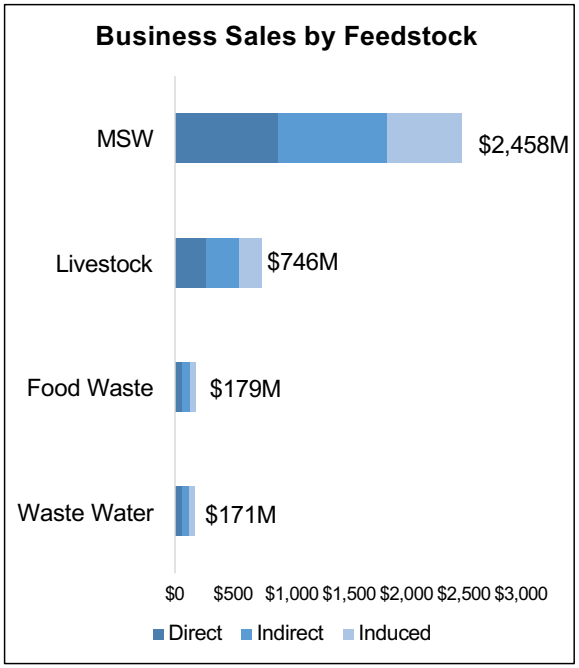


4 Economic Impact: MSW had the greatest economic impact from operations of the four feedstocks, accounting for 7,300 total jobs and supporting $1.2B in GDP and $2.5B in business sales in 2022

The economic impacts by feedstock type are presented below with most impacts supported by RNG produced from municipal solid waste (MSW) with over 7,300 jobs. The remaining 31% of all jobs are spread across the other three feedstocks.

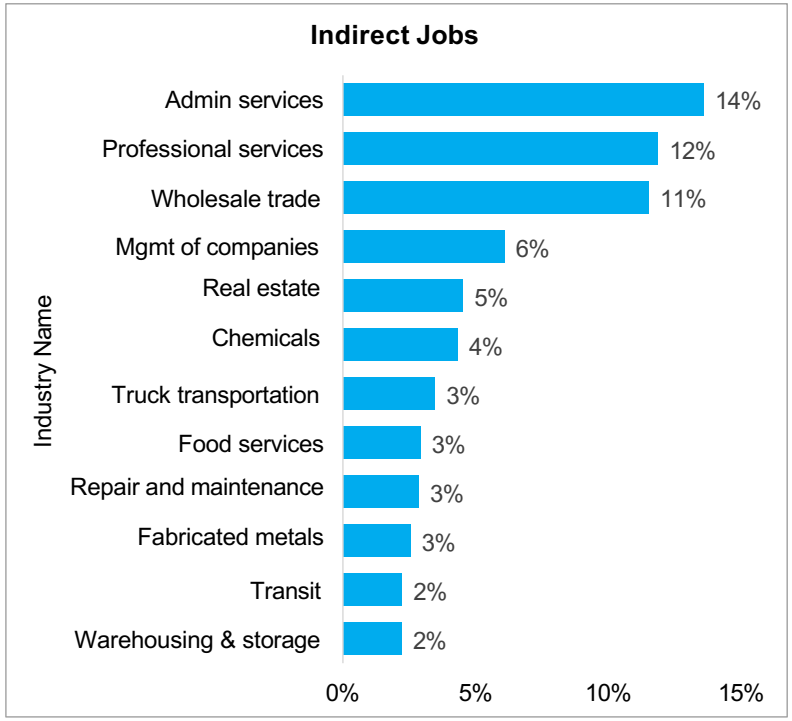


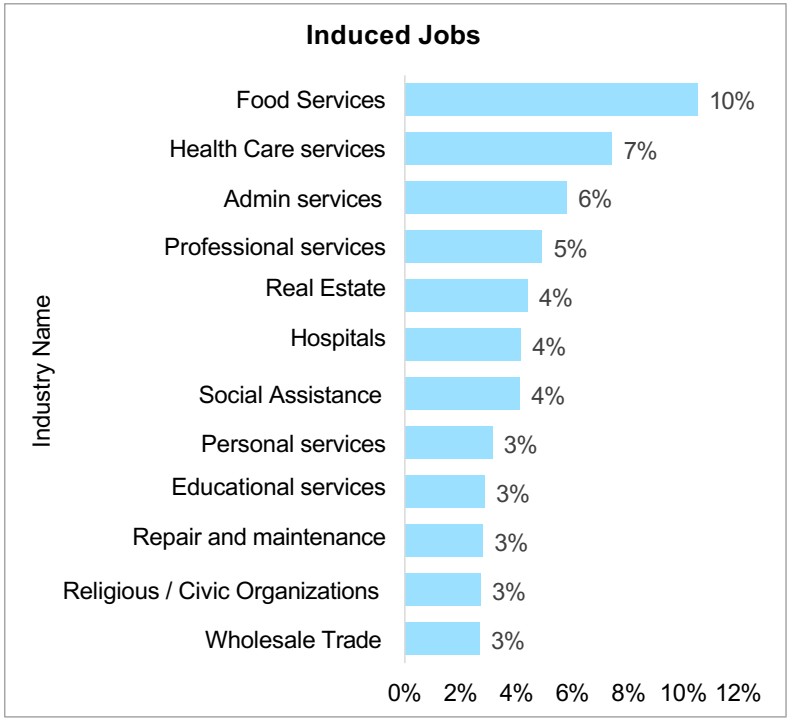




4 Economic Impact: Purchases within the supply chain based on buyer/supplier relationships generate indirect and induced jobs across a spectrum of industries

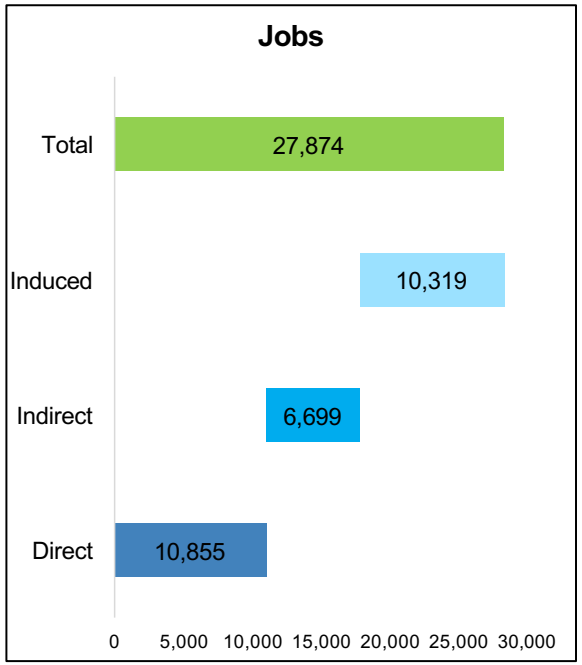
The industries with the most indirect jobs are administrative services, professional services, and wholesale trade. The industries with the most induced jobs are food services, health care services, and administrative services.

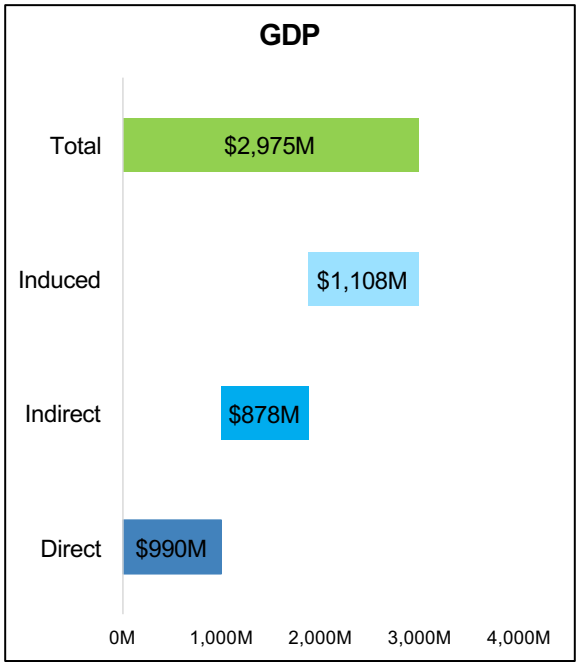


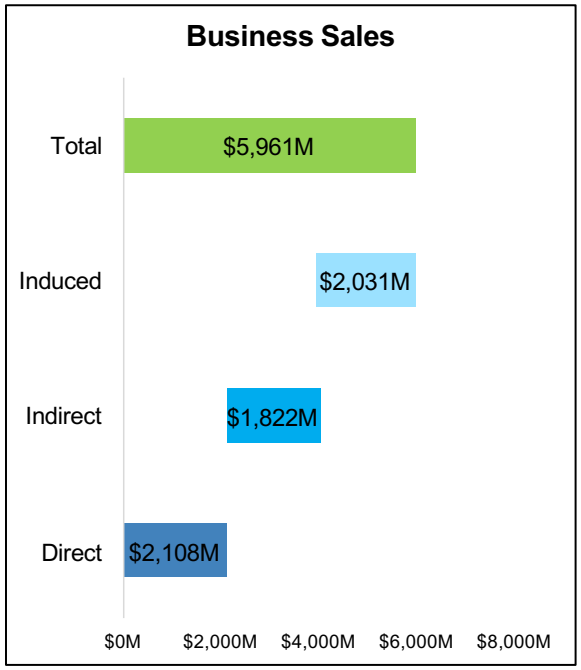


4 Economic Impact: RNG capital expenditures are estimated to support a total of 27,900 jobs, generate a total of $3.0B in GDP, and result in nearly $6B in business sales in 2022

Based on the spending for RNG Capital expenditures, the direct, indirect, and induced economic impacts are presented below in terms of jobs, GDP, and Business Sales.

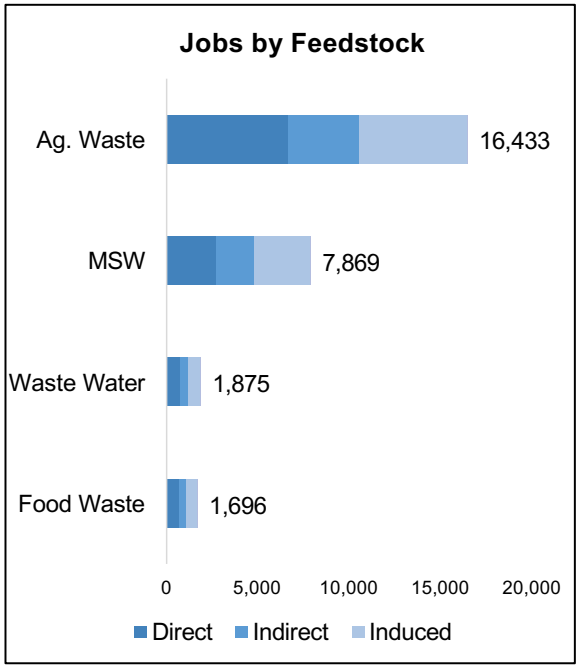


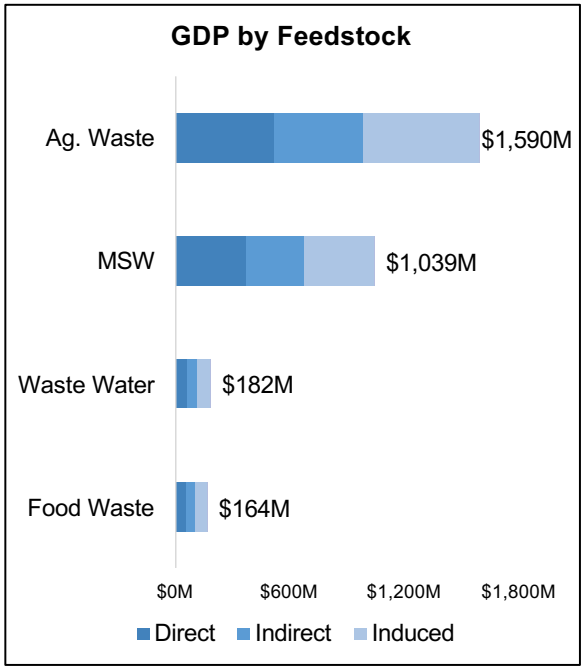


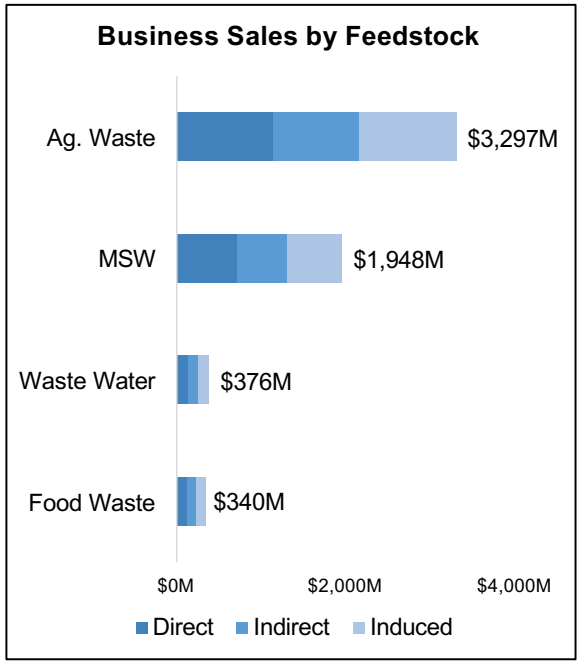


4 Economic Impact: Agricultural waste was estimated to have the greatest economic impact from capital expenditures of the four feedstocks, supporting 16,400 total jobs, generating $1.6B in GDP, and resulting in $3.3B in business sales

The economic impacts by feedstock type are presented below with most impacts supported by RNG produced from Agricultural Waste with 16,400 total jobs. The remaining 41% of all jobs are spread across the other three feedstocks.

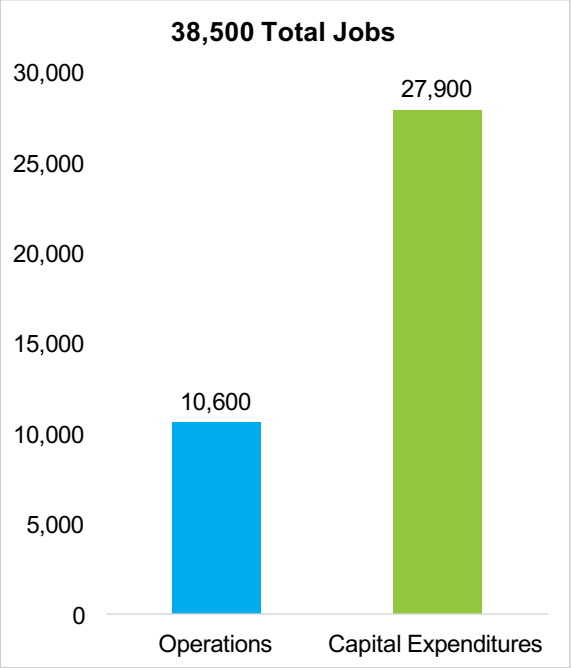


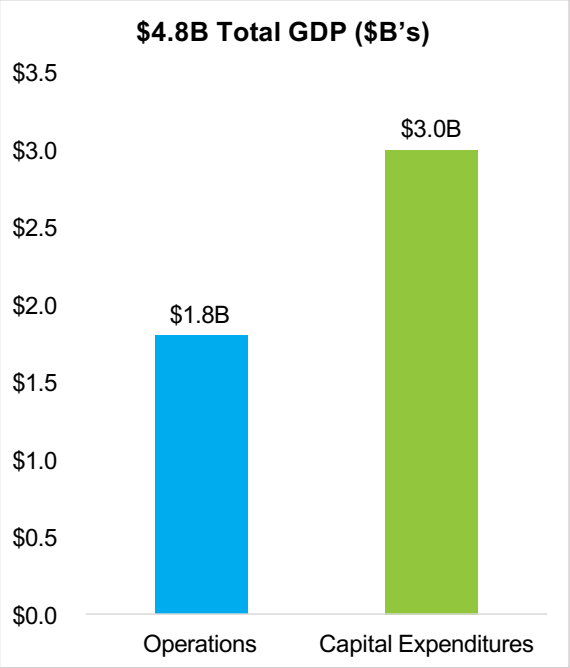




4 Economic Impact: Renewable natural gas is estimated to support 10,600 in jobs, generate $1.8B in GDP, and result in $3.5B in total business sales based on current operational capacity and 27,900 jobs, $3B in GDP, and $6B in total business sales for capital expenditures in 2022

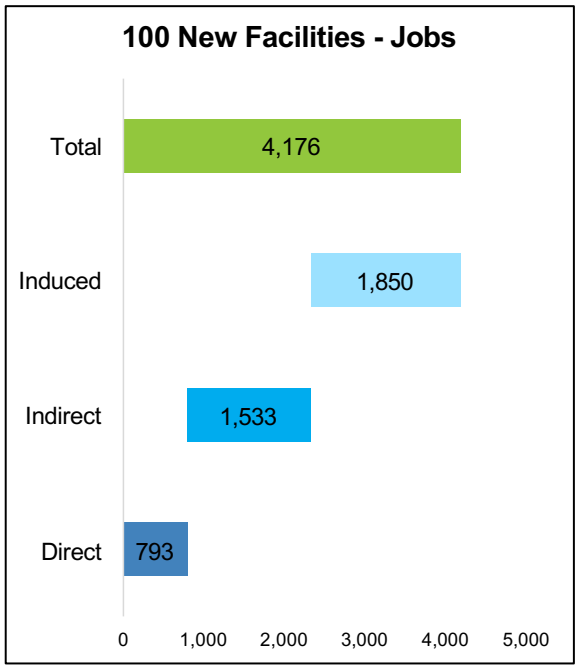
These numbers include the direct, indirect, and induced effects of RNG. Operations jobs are ongoing at completed RNG facilities however, capital expenditure or construction jobs terminate after approximately one year after a new facility is completed.

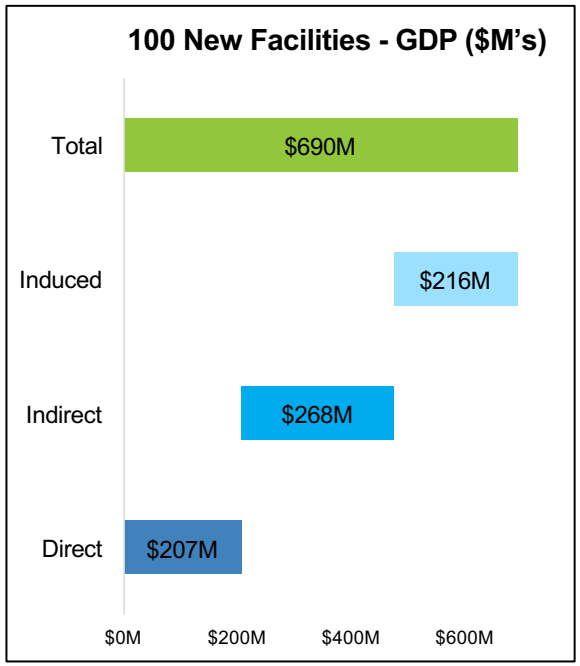


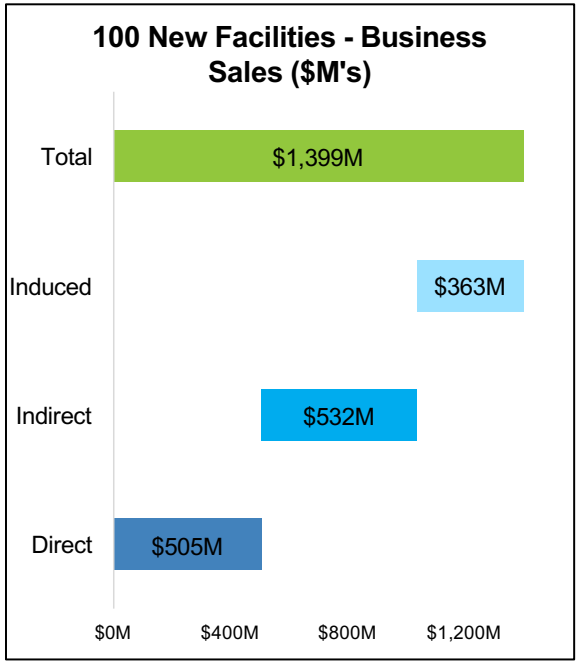


4 Economic Impact: Using the current inventory of RNG facilities, we estimated the economic impact for the operations and maintenance of 100 new RNG facilities

Nearly 800 direct jobs could be attributed the operations and maintenance of 100 new RNG facilities with a total of 4,200 jobs. 100 new facilities could also generate a total of $690M in GDP and nearly $1.4B in business sales.[16]



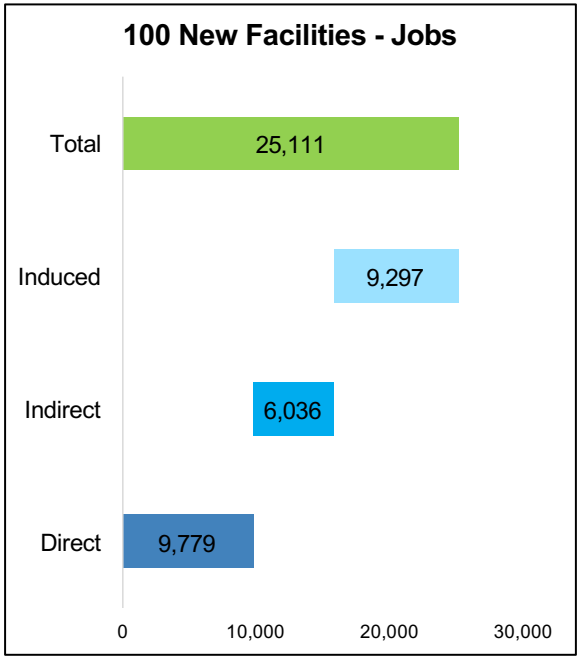


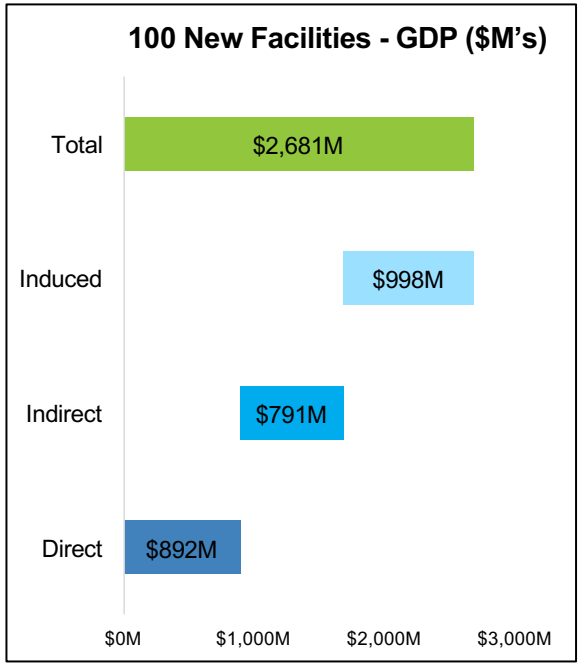


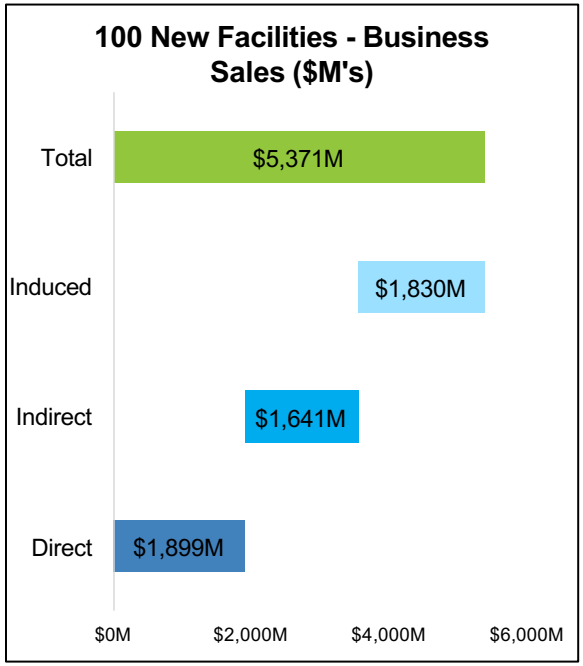
[16]Calculations are based on the average number of jobs per facility for each feedstock in 2022. Operations jobs ratios were calculated using current operation facilities in 2022. These numbers were provided by the RNG Coalition.

4 Economic Impact: Using the current inventory of RNG facilities, we estimated the economic impact for construction of 100 new RNG facilities

Nearly 9,800 direct jobs could be attributed the construction of 100 new RNG facilities with a total of 25,100 jobs. 100 new facilities could also generate a total of $2.7B GDP and nearly $5.4B in business sales.[17]



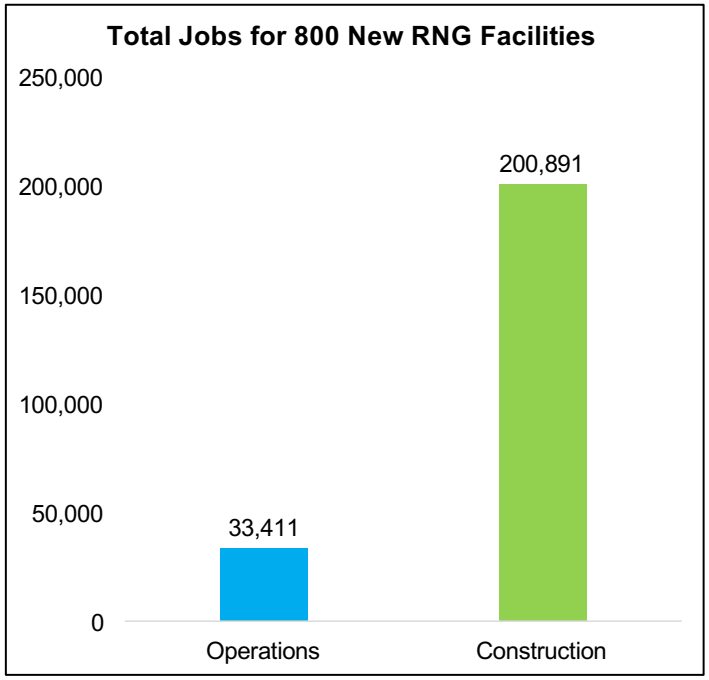


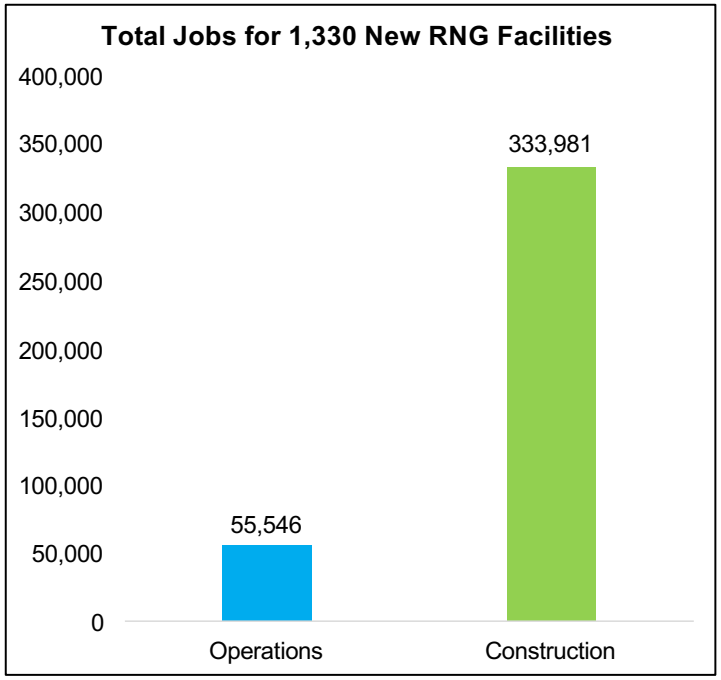


[17] Calculations are based on the average number of jobs per facility for each feedstock in 2022. Construction job ratios were calculated using the number of facilities currently under construction in 2022. These numbers were provided by the RNG Coalition.

4 Economic Impact: Using current estimates for the number of jobs per volume of RNG, we estimated the numbers of jobs created for 800 and 1,330 new RNG facilities

An additional 800 new facilities would create an estimated 33,400 total jobs from RNG production and 200,900 total construction jobs while 1,330 new facilities would create an estimated 55,500 total jobs from RNG production and 334,000 total construction jobs.[18]

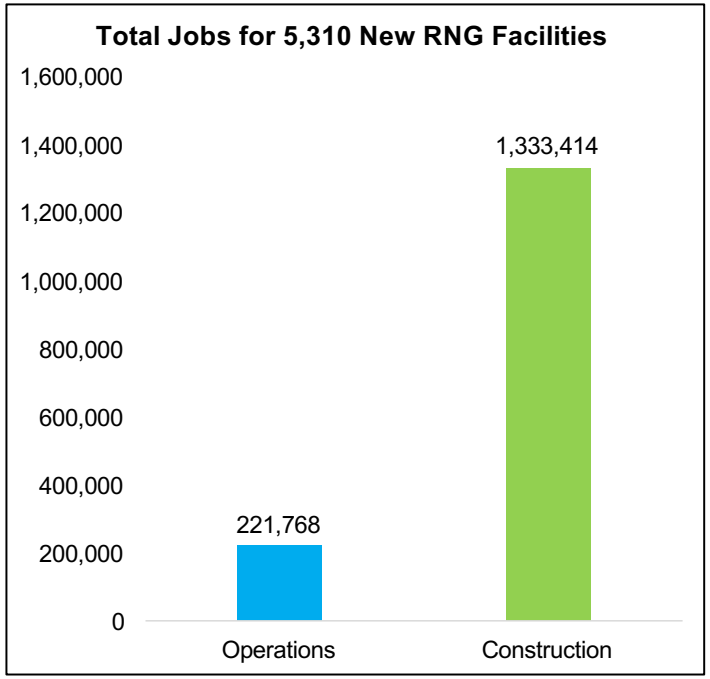


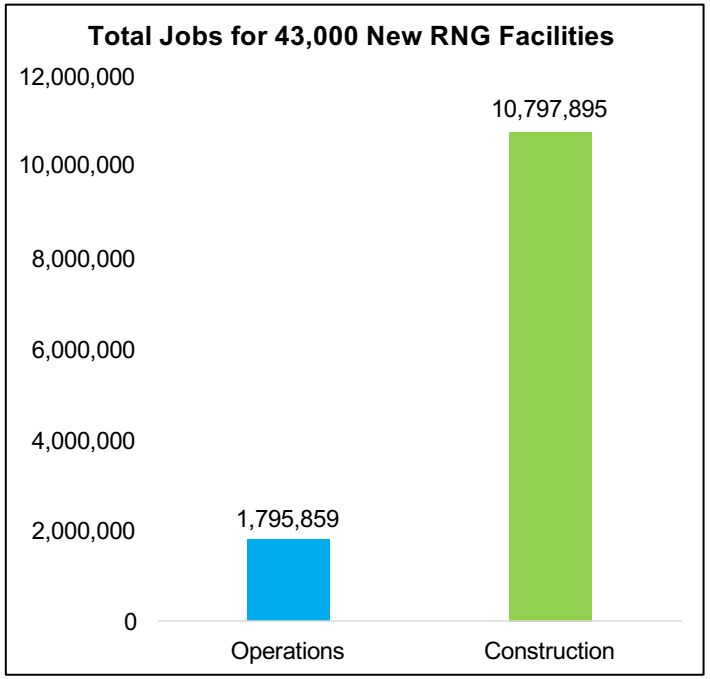


[18]Calculations are based on the average jobs per facility for each feedstock in 2022. Operations jobs ratios were calculated using current operation facilities in 2022 while construction job ratios were calculated using the number of facilities currently under construction in 2022. These numbers were provided by the RNG Coalition. These calculations do not take into consideration yearly economic changes that might affect RNG job numbers.

4 Economic Impact: Using current estimates for the number of jobs per volume of RNG and capital expenditures, we estimated the numbers of jobs created for 5,310 and 43,000 new RNG facilities

The IEA Global Report Model estimates 5,310 new facilities by 2050, which could create an estimated 221,800 additional total jobs from RNG production and 1.3M additional total construction jobs. RNG Coalition estimates that 43,000 new RNG facilities by 2050 based on its SMART goals would create an estimated 1.8M additional total jobs from RNG production and 10.8M additional total construction jobs.[19]





[19]Calculations are based on the average jobs per facility for each feedstock in 2022. Operations jobs ratios were calculated using current operation facilities in 2022 while construction job ratios were calculated using the number of facilities currently under construction in 2022. These numbers were provided by the RNG Coalition. These calculations do not take into consideration yearly economic changes that might affect RNG job numbers.

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