Industrial Facilities Stock Assessment: Phase One

Final Report

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Glossary of Key Terms

ACS – American Community Survey. The US government performs the American Community Survey (ACS) on an ongoing basis to provide information used to plan infrastructure and other vital services.

Btu – British thermal unit. The quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

CEI – Continuous Energy Improvement. This refers to a program that received a five-year market evaluation conducted by NYSERDA to gather location-level information from industrial facilities, specifically around energy management practices, generally targeted to the largest ones throughout the state. Surveys for this study were conducted biannually from 2017 to 2021. This program is now known as Energy Management Practices.

CO_2e – Carbon dioxide equivalents. This refers to the combined greenhouse gas effect of carbon dioxide, methane, and nitrous oxide, with methane and nitrous oxide's global warming potential normalized to that of carbon dioxide for comparison purposes.

DAC – Disadvantaged community. Disadvantaged communities are communities identified by state agencies, authorities, and entities to direct funding in a manner designed to achieve a goal of receiving 40% of overall benefits of spending on clean energy and energy efficiency programs per CLCPA requirement.[1] The identification of DAC communities in this report is based on its interim definition developed in 2020 and downloaded by DNV on June 17, 2022, which are:

- Located within census block groups that meet the HUD 50% AMI (Area Median Income) threshold, that are also located within the DEC Potential Environmental Justice Areas, or
- Located within New York State Opportunity Zones

EDI – Electronic Data Interchange. This refers to the New York State system available to partners to electronically request and receive consumption data for electric and gas customers, among other data in support of customer retail access.

Energy consumption. All direct energy used for heat and power at the facility, regardless of where the energy was produced.

Feedstock. Energy sources that are used for raw material input or for any purpose other than the production of heat or power.

[1] https://www.nyserda.ny.gov/ny/disadvantaged-communities

HGL – Hydrocarbon gas liquids. Hydrocarbon gas liquids (HGLs) are produced when raw natural gas is processed at natural gas processing plants and when crude oil is refined into petroleum products.[2] Hydrocarbons include ethane, propane, normal butane, isobutane, and natural gasoline.

IPE – Industrial and Process Efficiency Program. NYSERDA's IPE Program aimed to help manufacturers, data centers, and other production facilities increase output and improve processing as efficiently as possible. It has been closed to new applications since December 2019.

ISO 50001. ISO 50001 is a voluntary international standard developed by ISO, the International Organization for Standardization, that provides requirements for establishing, managing, and improving their energy consumption and efficiency.[3]

Low-carbon fuels. Alternative fuels such as natural gas or electricity that can replace carbon-intense petroleum products such as gasoline and diesel.

Manufacturing facility. A location where the manufacture of products from a raw material to a finished good using industrial production equipment and processes has been determined or is believed to be present. In this study, this is based on facilities a Manufacturing NAICS code from Data Axle that has passed the screening performed.

Manufacturing Energy Consumption Survey (MECS). A national sample survey that collects information on the stock of U.S. manufacturing establishment, their energy-related building characteristics, and their energy consumption and expenditures.[4]

North American Industry Classification System (NAICS). A numeric classification system to categorize facilities by processes or production.

North American Product Classification System (NAPCS). A numeric classification system of products (goods and services) that can be linked to a NAICS industry.

Physical unit. The physical unit of an energy source is that commonly used to measure a specific type of energy or fuel, e.g., barrels or gallons for liquid fuels, short tons for coal, cubic feet for natural gas, and kWh for electricity.

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[2] https://www.eia.gov/energyexplained/hydrocarbon-gas-liquids/where-do-hydrocarbon-gas-liquids-come-from.php#:~:text=Hydrocarbon%20gas%20liquids%20are%20derived%20from%20natural%20gas,from%20natural%20gas%20at%20natural%20gas%20processing%20plants.

[3] https://datascope.io/en/blog/what-is-iso-50001/

[4] https://www.eia.gov/consumption/manufacturing/about.php

Shipments. Manufacturers' shipments measure the dollar value of products sold by manufacturing establishments and are based on net selling values.

Industrial Tiers 1, 2, 3. NYSERDA industrial facility classification where Tier 1 is defined as having greater than $1 million in annual energy expenditures, Tier 2 is $500k to $1 million in annual energy expenditures, and Tier 3 is less than $500k in annual energy expenditures.

Variable Frequency Drives (VFDs). A VFD is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor.[5]

[5] https://vfds.com/

Executive Summary

The overall goal of the Industrial Facilities Stock Study is to provide a deep, data-driven understanding of New York State's (NYS) manufacturing (NAICS 31-33) and greenhouse sectors by providing information regarding industrial facility firmographics, location, proximity to disadvantaged communities (DACs), energy use characteristics, and clean energy opportunities. There are two key phases to this study. This report presents the Phase One research. The objectives, purpose, and methods of each phase are summarized in Table ES-1.

Table ES-1. Study objectives, purposes, and methods

Objective	Purpose	Methods
Phase One		
Gather and synthesize available existing manufacturing and greenhouse data (Phase One)	Characterize subsectors to develop a baseline understanding of NYS's industrial facilities to inform future work to identify industrial facilities' potential for meeting NYS Climate Leadership and Community Protection Act (CLCPA) goals	• Secondary research and data acquisition • Develop screened, augmented database of address-level characteristics with imputations as needed
Determine proximity of manufacturing and greenhouse facilities to disadvantaged communities in NYS (Phase One)	Provide background necessary to ensure equitable implementation of CLCPA goals among manufacturing and greenhouse subsectors	• Geocoding of facilities to nearest disadvantaged community based on direct distance, driving distance, or walking distance with mass transit
Develop Phase Two subsector priorities for primary research	Determine industrial subsectors exhibiting significant opportunities for carbon and greenhouse gas reductions for primary data collection in Phase Two	• Examine key metrics from Phase One to select and recommend candidate subsectors for primary data collection in Phase Two
Phase Two		
Gather and document information from primary research at a statistically selected sample of manufacturing subsectors and greenhouses targeted based on Phase One	Provide refined baselines for programs, clean energy achieved calculations, clean energy potential studies, and establish a time series dataset of the market to understand the impact of future market effects	• Computer Assisted Telephone Interviewing (CATI) and Phone surveys of targeted manufacturing subsectors and greenhouses • On-site and virtual site visits of at targeted manufacturing subsectors and greenhouses (subsequent to CATI/Phone surveys)

Manufacturing Subsector Secondary Research Findings

There are four categories of data sources used in Phase One. These include included proprietary facility-level sources (e.g., Data Axle, Dodge, and RS Means), federal sources (e.g., United States Energy

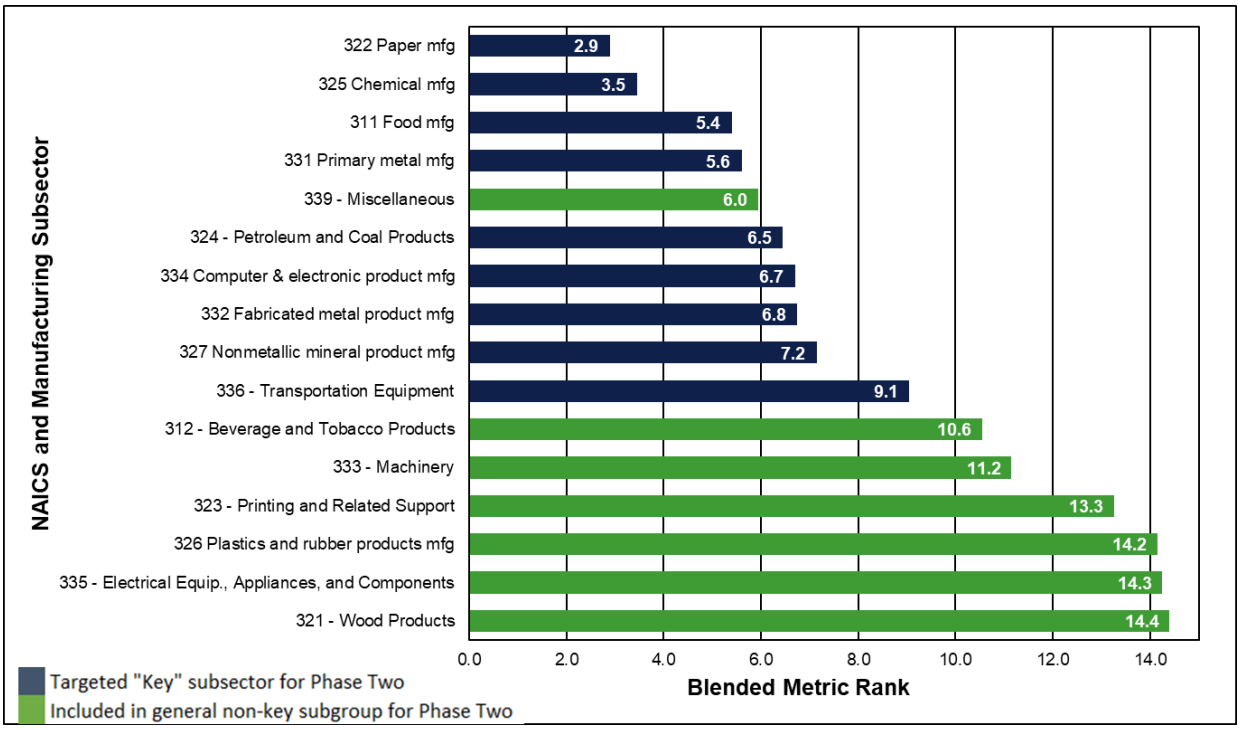
Information Administration Manufacturing Energy Consumption Survey (MECS), Economic Census, Environmental Protection Agency Facility Level Information on Greenhouse Gases Tool (EPA FLIGHT), and the Industrial Assessment Center (IAC)), NYSERDA sources (program and distributed energy resources (DER) data repositories, disadvantaged community lists, Salesforce, and Continuous Energy Improvement (CEI) Market Evaluation data), and the New York Greenhouse and Nursery license list. The data and information from these sources were integrated to identify the New York state population of manufacturing facilities, their subsector type, and locations. This was followed by direct or imputed calculations using secondary data of key features by subsector. These features include, among other things, energy expenditures, greenhouse gas (GHG) emissions, number of employees, size (square feet), energy management practices, value of shipments, and opportunities for fuel switching and electrification. Weights were developed to characterize these features for each subsector. Detailed tables showing these results are provided in the body of this report.

As each key result was produced, a subsector rank of where that subsector fell accompanied the results. Ranks began at 1 for the highest value of a given result, 2 for next highest, etc. (e.g., the subsector with the highest estimated employment had a rank of 1, the subsector with the highest estimated GHG emissions had a rank of 1). The study team developed a weighted average[6] of these ranks across five key sets of results including total emissions, consumption, employment, value of shipments, and energy expenditures. This collection of results and weights were selected to balance various considerations in the identification of manufacturing subsectors with clean energy potential.

Figure ES-1 shows the average weighted ranks for each subsector using the five results identified. The subsectors colored in blue are recommended for Phase Two targeting. Those in green are recommended for inclusion in the Phase Two non-key group. The top three manufacturing subsectors using this approach are Paper Manufacturing (322), Chemicals Manufacturing (325), and Food Manufacturing (311).

[6] Total consumption weight 0.15, total employment weight 0.1, total emissions weight 0.25, total value of shipments weight 0.25, total energy expenditures weight 0.25

Figure ES-1. Sector by blended metric rank



Disadvantaged Communities Findings

The DAC analysis revealed that the relationship of employment and manufacturing sites is not homogenous statewide, with significant variability at the regional and local levels. Identification of local areas that have few or no employment opportunities in proximity, either in totality or by specific industries, can provide guidance on where economic development or transportation solutions might be most effective at improving manufacturing employment rates among DACs.

The DAC results showed substantial variance in industrial employment resiliency that different communities face. In some instances, the jobs available to regional residents of DACs are relatively unremarkable in aggregate but are also highly concentrated in one or two firms. Changes in these firms' business could, for these local communities, substantively change the accessibility of employment for DACs. In other regions of the state, a lower proportion of employment available to residents of DACs are mitigated by a larger number and diversity of facilities resulting in a more robust employment landscape.

Approximately 33% of site CO_{2e} emissions originate inside DAC block groups. There are several regions with intense CO_{2e} emissions in DACs that have industrial facilities. Including other facilities in proximity to DAC block groups, the total emissions affecting some DACs may be much higher.

1 Phase One Goals and Description

The goal of the overall Industrial Facilities Stock Study is to provide a deep, data-driven understanding of New York's manufacturing (NAICS 31-33) and greenhouse sectors by providing information regarding industrial facility size, location, proximity to disadvantaged communities (DACs), energy use characteristics, and energy efficiency, electrification, and carbon reduction improvements already undertaken. This project will help identify the industries, manufacturing facilities, and end uses that offer opportunities for greenhouse gas reductions, energy efficiency, beneficial electrification, and renewable energy for achieving the New York State Climate Leadership and Community Protection Act (CLCPA) 2050 goals.[7] Data will be produced for subsectors defined by three-digit NAICS code for the manufacturing sector, and for a greenhouse subsector defined as those facilities in NAICS code 1114 that are not nursery or floriculture.

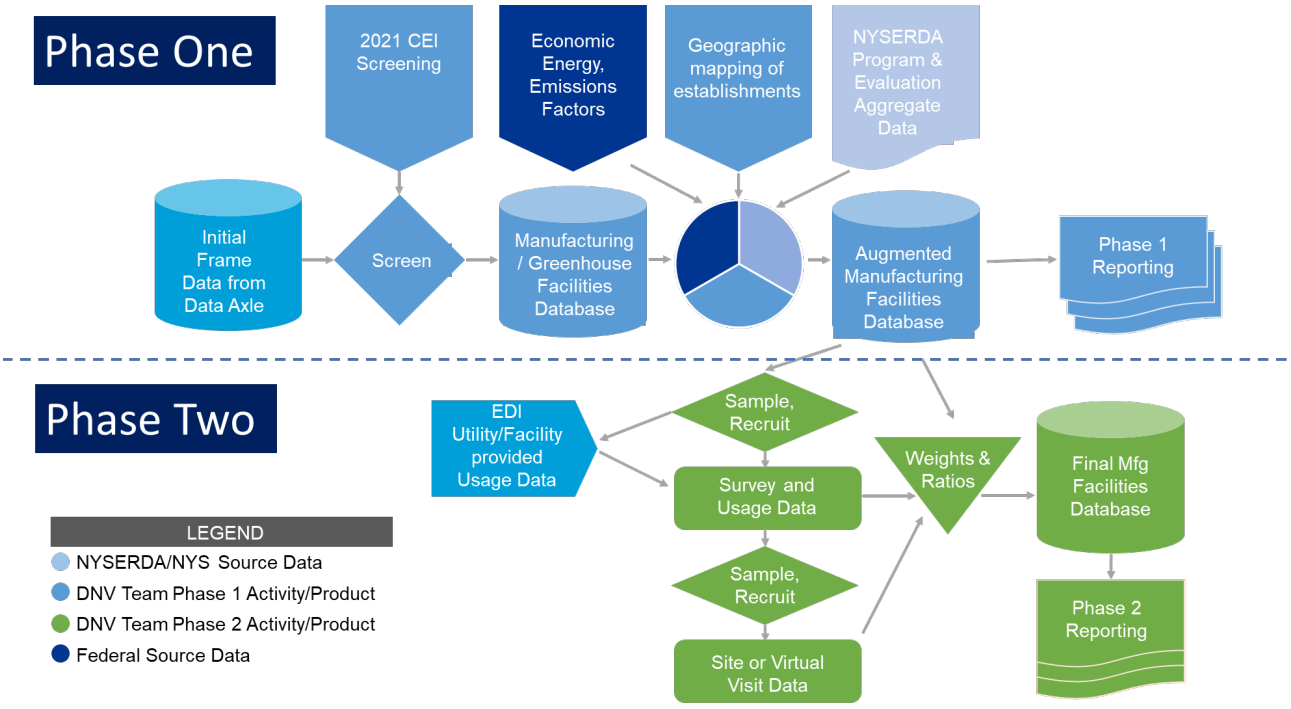
There are two key phases to this study. Phase One establishes an initial industrial and greenhouse baseline by synthesizing existing secondary data and research on NYS industries by subsector in terms of multiple dimensions related to energy use, practices, and equipment. This report contains these results. This information will be a central part of a planned industrial potential study due to the NY State Department of Public Service (DPS) by June 1, 2023.

Phase Two will build off Phase One with primary data research targeted to key industrial subsectors, including Computer Assisted Telephone Interviewing (CATI) surveys, virtual on-sites, and physical on-sites. Key industrial subsectors are identified for Phase Two work based on their clean energy potential, energy intensity, energy-using equipment, and other characteristics observed in Phase One. Phase Two will further refine the characterizations made in Phase One and provide additional dimensions including presence of waste capture and recycling processes, planned system improvements, and high-level equipment inventories.

Figure 1-1 shows the relationship between Phase One (above the dashed line) and Phase Two (below the dashed line).

[7] 85% reduction in greenhouse gas emissions from 1990 levels by 2050, 70% of electricity generation from renewable sources by 2030 and 100% zero-carbon electricity by 2040

Figure 1-1. Industrial stock characterization process overview



This report summarizes the methods, results, conclusions, and recommendations of Phase One, and concludes with a discussion of recommended targets for Phase Two.

Table 1-1. Study objectives, purposes, and methods

Objective	Purpose	Methods
Gather and synthesize available existing manufacturing and greenhouse data	Characterize subsectors to develop a baseline understanding of NYS's industrial facilities to inform future work to identify industrial facilities' potential for meeting NYS CLCPA goals	• Secondary research and data acquisition • Develop screened, augmented database of address-level characteristics with imputations as needed
Determine proximity of manufacturing and greenhouse facilities to disadvantaged communities in NYS	Provide background necessary to ensure equitable implementation of CLCPA goals among manufacturing and greenhouse subsectors	Geocoding of facilities to nearest disadvantaged community based on direct distance, driving distance, or walking distance with mass transit
Develop Phase Two subsector priorities for primary research	Determine industrial subsectors exhibiting significant opportunities for carbon and greenhouse gas reductions for primary data collection in Phase Two of the work	• Examine overall Btu consumption, drivers, and clean energy improvements already made at the subsector level • Select and recommend candidate subsectors to NYSERDA for primary data collection in Phase Two

2 Methods

This section documents the data sources used, the cleaning and screening methods employed to prepare the data for analysis, and the scaling and imputations performed to estimate the results for each characteristic.[8]

2.1 Data Sources

There are four primary sources of data used in this study. They include data available from the federal government, NYSERDA, New York State, and other sources, including industry data subscriptions or other privately held data. The study reviewed many candidate sources and identified those with usable information. The study team includes the sources used in Table 2-1, Table 2-2, Table 2-3, and Table 2-4. Appendix A provides detailed information on the fields used from each source and the manner they were used to produce the results tables.

Table 2-1. Proprietary facility-level sources

Source	Description	How used
Data Axle	Listing of all companies with industrial NAICS codes of interest (22), including fields on number of employees, address, contact information, and coordinates, among other information	Provided the foundation for the manufacturing subsector population that was then screened to identify only facilities with manufacturing operations at each location. Imputed values from other sources were appended to the final screened Data Axle dataset.
FW Dodge Data	Listing of all recently constructed facilities with industrial NAICS codes of interest (22)	Facilities that have manufacturing operations were appended to the Data Axle population to ensure comprehensiveness.
RS Means	A dataset of current construction cost estimates, including materials, labor, transportation, and storage.	Used to impute square footage for Dodge projects when only project cost available.[9]

Four primary federal resources with specific datasets were used in this study and are detailed in Table 2-2.

[8] Characteristics by manufacturing subsector includes of facilities (overall and by Tier), employees, square feet, consumption, on-site renewable generation, installed solar/fuel cell/storage capacity, and greenhouse gas emissions.

[9] https://www.rsmeans.com/media/wysiwyg/quarterly_updates/2021-projectcosts.pdf

Table 2-2. Federal sources

Source	Description	How used
2018 MECS[10]	Table 8.1: Number of Establishments by Participation in General Energy-Management Activities	Provided data on various energy management and retrofit activities undertaken overall and by NAICS code
2018 MECS	Table 6.1: Consumption Ratios of Fuel	Provided regional data on energy consumption per employee by NAICS code used in conjunction with Table 7.2 to calculate estimated monetary cost of energy expenditure
2018 MECS	Table 7.2: Average Prices of Purchased Energy Sources	Provided regional data on energy cost ($/MMBtu) by NAICS code, used in conjunction with Table 6.1 to calculate estimated monetary cost of energy expenditure
2018 MECS	Table 1.1: First Use of Energy for All Purposes (Fuel and Nonfuel)	Provided national data on total energy consumed per NAICS code. Used in conjunction with Table 9.1 to calculate total consumption per square foot
2018 MECS	Table 9.1: Enclosed Floorspace and Number of Establishment Buildings	Provided national data on enclosed floorspace of all facilities by NAICS category, used in conjunction with Table 1.1 to calculate total consumption per square foot
2018 MECS	Table 1.2: First Use of Energy for All Purposes (Fuel and Nonfuel)	Provided regional data of energy usages broken down by energy types. Used in conjunction with Table 5.2 to calculate end uses of energy consumed
2018 MECS	Table 5.2: End Uses of Fuel Consumption	Provided national data on energy end uses in Btus, paired with Table 1.2 to estimate end uses at the three-digit NAICS level
2018 MECS	Table 5.1: End Uses of Fuel Consumption	Provided national data on energy end uses in Physical Units or Btus, paired with Table 1.2 to estimate end uses at the three-digit NAICS level
2018 MECS	Table 3.2: Fuel Consumption	Provided fuel consumption at the three-digit NAICS level, used to calculate greenhouse gas emissions
2018 MECS	Table 10.3: Number of Establishments with Capability to Switch Natural Gas to Alternative Energy Sources	Provided national percentage of establishments that can switch from natural gas to electricity
2018 MECS	Table 10.5: Number of Establishments with Capability to Switch Residual Fuel Oil to Alternative Energy	Provided national percentage of establishments that can switch from residual fuel oil to electricity and/or natural gas
2018 MECS	Table 10.9: Number of Establishments with Capability to Switch Distillate Fuel Oil to Alternative Energy	Provided national percent of establishments that can switch from distillate fuel oil to electricity and/or natural gas
2018 MECS	Table 10.11: Number of Establishments with Capability to Switch Coal to Alternative Energy Sources	Provided national percent of establishments that can switch from coal to electricity and/or natural gas
2018 MECS	Table 10.13: Number of Establishments with Capability to Switch HGL (excluding natural gasoline) to Alternative Energy Sources	Provided national percent of establishments that can switch from HGL to electricity and/or natural gas

[10] https://www.eia.gov/consumption/manufacturing/data/2018/

Source	Description	How used
2017 Economic Census[11]	EC1731MATFUEL: Manufacturing: Materials Consumed by Kind of Industry for the U.S.	Provided dollar value of material costs into manufacturing facilities at the state, regional and national levels
2017 Economic Census	EC1731BASIC: Manufacturing: Summary Statistics for the U.S., States, and Selected Geographies	Provided dollar value of shipments from manufacturing facilities at the state, regional and national levels
2017 Economic Census	EC1700NAPCSINDPRD: Detailed data of manufactured products, produced by each NAICS code, at the state level	Provided detailed statistics of manufactured products for each NAICS manufacturing category, used to determine product revenue from manufacturing facilities for New York State
2017 Economic Census	EC1700NAPCSINDPRD: Detailed data of manufactured products, produced by each NAICS code at the national level	Provided detailed statistics of manufactured products for each NAICS manufacturing category, used to determine product revenue from manufacturing facilities, at the national level.
2017 Economic Census	2017 NAPCS Trilateral Product Codes to NAPCS-Based Collection Codes	A comprehensive classification system that links products to the NAICS classification structure, used to detail products produced in each manufacturing subsector (2- to 6-digit NAICS codes)
U.S. EPA	GHG Emissions Factors Hub[12]	This table provided greenhouse gas emission factors used in greenhouse gas emissions calculations
U.S. EPA	Facility Level Information on Green House gases Tool (FLIGHT) Data[13]	This site contains information on the largest GHG emitters in NYS and was used to identify manufacturing presence
D.O.E IAC[14]	Dept. of Energy Industrial Assessment Centers (IAC)	IAC database of assessments, contains site-level employment information. Used to calculate energy expenditure

[11] https://www.census.gov/data/tables/2017/econ/economic-census/naics-sector-31-33.html

[12] https://www.epa.gov/climateleadership/ghg-emission-factors-hub

[13] https://ghgdata.epa.gov/ghgp/main.do

[14] https://iac.university/searchAssessments

Table 2-3. NYSERDA sources

Source	Description	How used
Continuous Energy Improvement Market Evaluation (CEI) Data[15]	NYSERDA performed a data collection effort as part of market evaluations to support the CEI program in 2017, 2019, and 2021. The studies included screening of all Tier 2 and Tier 2 facilities and samples of Tier 3[16] facilities, to identify facilities with manufacturing activity	Provided a primary source to screen non-manufacturing locations from the population, as well as identifying energy management culture and practices, and contact information
Disadvantaged communities list[17]	Communities identified as disadvantaged with a collective target of receiving 40% of overall benefits of spending on clean energy and energy efficiency programs	Provided key information for the network and geospatial mapping of manufacturers to disadvantaged communities
Manufacturing improvement fact sheets	NYSERDA has published fact sheets that capture typical manufacturing processes and clean energy opportunities (e.g., energy-efficiency) for the largest manufacturer sectors in the state	Provided key information on typical energy use, production/ process equipment and improvements opportunities for nine three-digit NAICS codes
Salesforce	NYSERDA tracks activity and outreach activities for many efficiency programs in a database called Salesforce.	Provided information used to designate manufacturing presence at individual locations
Clean Energy Upgrades Calculator V5[18]	NYSERDA has published a greenhouse gas emissions calculator, with emission factors calculated to accurately reflect local energy usage in New York Sate	This table provided GHG emission factors used to calculate GHG emissions for the DAC analyses
Projected Emission Factors for New York Grid Electricity[19]	NYSERDA has published greenhouse gas emissions factors for electricity consumption that meet the requirements of emissions accounting for the Climate Act.	This document provided emissions factors for calculating total electric GHG emissions by industrial subsector
Fossil and Biogenic Fuel Greenhouse Gas Emissions Factors[20]	NYSERDA has published greenhouse gas emissions factors for fossil fuel consumption that meet the requirements of emissions accounting for the Climate Act.	This document provided emissions factors for calculating total fossil fuel GHG emissions by industrial subsector
Industrial and Process Efficiency Program (IPE)	IPE was administered by NYSERDA and provides energy efficiency assistance to manufacturers and data centers.	This source provided participant company name and county that was used as part of screening facilities for manufacturing activity

[15] Continuous Energy Improvement Market Evaluation 2019 Final Report, NYSERDA, Prepared by Cadmus, April 2020

[16] Tiers I, II, and III are NYSERDA manufacturing facility categories defined by level of energy expenditure. The methods used to calculate and assign facilities to these tiers are further discussed in Section 3.1.1.

[17] https://climate.ny.gov/Our-Climate-Act/Disadvantaged-Communities-Criteria/Disadvantaged-Communities-Map

[18] https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Communities/How-It-Works/Toolkits/Clean-Energy-Upgrades

[19] https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-18-Projected-Emission-Factors-for-New-York-Grid-Electricity.pdf

[20] https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-23-Fossil-and-Biogenic-Fuel-Greenhouse-Gas-Emission-Factors.pdf

Source	Description	How used
NYS Distributed Energy Resource Repository[21]	A database of DER projects that have received NYSERDA incentives or voluntarily shared information on their energy storage projects.	Provided list of solar and energy storage projects for industrial facilities

Table 2-4. New York State sources outside NYSERDA

Source	Description	How used
Greenhouse and Nursery state license list[22]	A listing of all certified nursery growers and greenhouses which are licensed by the NYS Department of Agriculture and Markets	Provided the foundation for the greenhouse facility population and capacities installed

2.2 Aggregation of Data

To construct a population of industrial facilities for this study, the team started with a database of facilities in the 31-33 NAICS sectors provided by Data Axle, up to date as of Quarter 1 2022. In addition to Data Axle, FW Dodge new construction data were used to identify any potentially new manufacturing facilities constructed in the past few years which may not yet have been screened by Data Axle. EPA's FLIGHT database for New York State, which identifies the largest greenhouse gas emitters in the state, was also used as a source to identify additional large manufacturing facilities in the event they did not appear in the Data Axle population. Data were merged using a combination of cleaned address, geocoded address, and fuzzy matching[23] of customer name, where the match allowed for spelling variation in customer name between the three datasets.

As shown in Figure 2-1, the initial Data Axle population included 19,875 manufacturing and greenhouse facilities. Merging on the Dodge data to the sample frame resulted in an overlap of 91 facilities, with 861 Dodge facilities not merging. These facilities were manually screened for industrial activity, with 48 being added to the Data Axle population as additional manufacturing records. The remaining 813 records in the Dodge data were identified as either not yet constructed, a warehouse or parking garage project, or constructed but not yet occupied by any tenant.

Merging the FLIGHT data to the Data Axle population resulted in an overlap of 21 facilities, with 40 facilities not merging and requiring manual screening. Of these, 20 were identified as eligible active industrial facilities and added to the Data Axle population. Of the remaining 20 records, 9 were identified

[21] https://der.nyserda.ny.gov/search/

[22] https://data.ny.gov/Economic-Development/Nursery-Growers-and-Greenhouse/qke7-n4w8

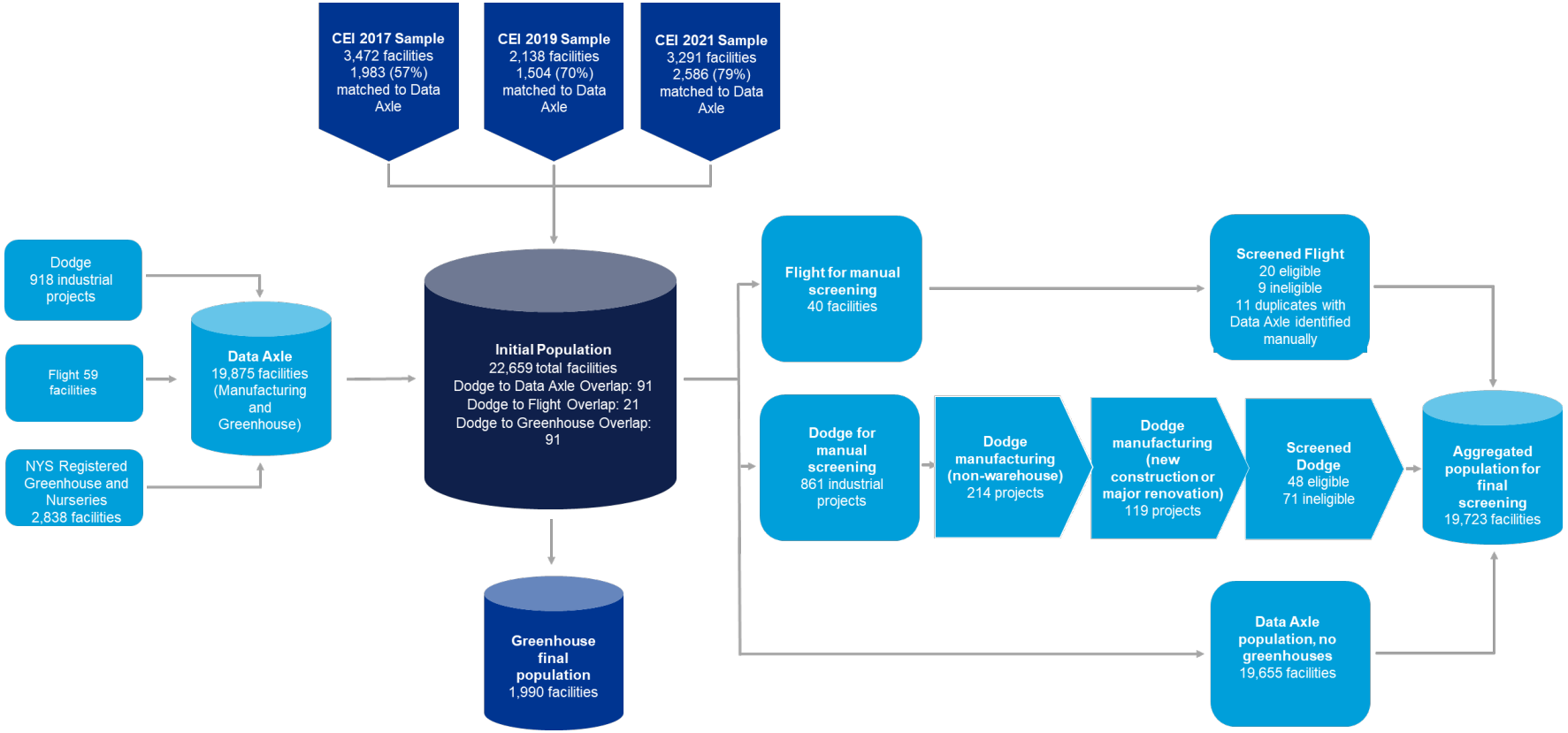
[23] The systematic approach taken to match records from disparate datasets assessing the similarity of segments of text in company names and/or address fields for each dataset

as having closed or no longer supporting manufacturing, while 11 were identified as overlapping the Data Axle population, but which had not been identified during the initial merge due to a name change.

In addition to the Dodge and FLIGHT data, sample designs from the NYSERDA CEI Market Evaluation surveys were merged onto the population to screen facilities as manufacturing, non-manufacturing, or unknown, based on the survey dispositions from those surveys. Merging was done in a similar manner to the Dodge and FLIGHT data, with the exception that if an address matched between one of the CEI Market Evaluation samples and the Data Axle data, and the facility size was the same in both datasets, this counted as a match even if the customer's name did not match. This was done to improve match rates due to several differences in customer names between the CEI Market Evaluation samples and Data Axle population, which a manual review of a sample of records determined were the often the same company. Of the 3,472 facilities in the 2017 CEI survey sample, 57% matched to the Data Axle population, with 70% of the 2,138 facilities in the 2019 CEI survey sample matching, and 79% of the 3,291 facilities from the 2021 sample. This increase in match rates between sample years was expected due to facilities opening and closing from the beginning of the CEI Market Evaluation to present day.

After aggregating the data, two final datasets were produced: one for industrial analysis containing 19,723 facilities, and one for greenhouse analysis containing 1,990 facilities.

Figure 2-1. Industrial facility population aggregation process



2.3 Screening of Population

As referenced in Section 2.2, dispositions from the CEI Market Evaluation sample designs were appended to the population of industrial facilities to determine whether each listed facility was engaged in manufacturing or was instead performing some other manufacturing-related role (corporate headquarters, warehouse) and not engaged in production. Table 2-5 shows the results of that screening process. While the CEI surveys attempted to contact all Tier 1 and most Tier 2 facilities, the CEI Market Evaluation and Industrial Stock Assessment Study used different tier definitions, requiring additional screening of Tier 1 and Tier 2 apart from the CEI data.[24]

To complete the additional required screening, participant tracking data, Salesforce outreach data, manual lookups, and phone interviews were used. The participant tracking data contained records of facilities that had gone through NYSERDA's IPE program, which if merged to a record from Data Axle, FLIGHT, or Dodge would confirm its status as a manufacturing facility. Similarly, the Salesforce data consisted of facilities that NYSERDA had already screened for manufacturing program outreach.

For Tier 1 and Tier 2 records that did not link to either the IPE data or the Salesforce data, manual screening was conducting by doing an internet search for each facility. If it was not obvious from the internet search whether a facility was engaged in manufacturing, the study attempted to call the facility to confirm its status. If a facility could not be reached by phone, it was labeled "indeterminate" and received an analysis weight, which is discussed in Section 2.4.

Overall, this study identified that of the initial population of NAICS 31-33 facilities in Data Axle, FLIGHT, and Dodge combined that could be screened, 78% of Tier 1, 74% of Tier 2, and 60% of Tier 3 facilities were actual manufacturing facilities, with the remaining screened facilities engaged in non-manufacturing activities.

[24] The CEI Market Evaluation based their tiers on number of employees per facility: Tier III – less than 100 employees, Tier II – 100 to 249 employees, Tier III – greater than or equal to 250 employees. This study assigned tiers based on imputed energy expenditures: Tier III – less than $500k per year, Tier II - $500k-1,000k per year, Tier I – greater than $1,000k per year.

Table 2-5. Manufacturing facility screening results

Facility Tier	Full Disposition	Full Disposition N	Collapsed Disposition	Collapsed Disposition N	Percent of Screened Facilities with Confirmed Manufacturing Activity
Tier 1	Eligible	105	Total Eligible	190	78%
	Eligible - FLIGHT	4			
	Eligible - Manual Lookup	47			
	Eligible - Salesforce	33			
	Eligible - Tracking	1			
	Ineligible	42	Total Ineligible	53	
	Ineligible - Manual Lookup	11			
	Indeterminate - No Response to Phone Screening	1	Total Not Screened	1	
	Tier 1 Screened Population			**243**	
	Tier 1 Overall Population			**244**	
Tier 2	Eligible	226	Total Eligible	433	74%
	Eligible - FLIGHT	4			
	Eligible - Manual Lookup	164			
	Eligible - Salesforce	37			
	Eligible - Tracking	2			
	Ineligible	107	Total Ineligible	151	
	Ineligible - Manual Lookup	44			
	Indeterminate - No Response to Phone Screening	4	Total Not Screened	4	
	Tier 2 Screened Population			**584**	
	Tier 2 Overall Population			**588**	
Tier 3	Eligible	433	Total Eligible	821	60%
	Eligible - FLIGHT	6			
	Eligible - Manual Lookup	202			
	Eligible - Salesforce	174			
	Eligible - Tracking	6			
	Ineligible	489	Total Ineligible	550	
	Ineligible - Manual Lookup	61			
	Not Screened	17,529	Total Not Screened	17,529	
	Tier 3 Screened Population			**1,371**	
	Tier 3 Overall Population			**18,900**	

2.4 Weighting

As a substantial portion of this study's analysis involves imputing facility-specific metrics (e.g., energy consumption, value of shipments) for the population of industrial facilities defined in Section 2.2. Aggregating those values to manufacturing subsectors and the population required application of an

analysis weight to those facilities the study was unable to confirm were involved in manufacturing. This involved a small number of Tier 1 and Tier 2 facilities, and a much larger number of Tier 3 facilities. Additionally, it was identified that the proportion of screened Tier 3 facilities with manufacturing was substantially different in New York City versus the rest of the state, so weights were calculated separately for Tier 3 in those facilities in NYC vs those facilities outside of NYC.

The analysis weight is the proportion of facilities found to be involved in manufacturing among the screened population of each NAICS subsector for the Data Axle population. These weights are shown in Table 2-6. There were four Tier 1 and Tier 2 subsectors, and one Tier 3 subsector where eligibility was unknown for all screened facilities (identified as bold text in the table). For these, the study applied the overall tier eligibility weight of 0.78 for Tier 1, 0.70 for Tier 2, 0.67 for Tier 3 statewide, and 0.26 for Tier 3 in New York City.

Additional manufacturing facilities identified in the FLIGHT or Dodge data as described in Section 2.2 are not included in the weights calculations since these facilities were universally screened, with facilities having indeterminate manufacturing limited to the base Data Axle database. That is why the overall weights shown in Table 2-6 do not match the percentages of screened facilities with manufacturing activity (including FLIGHT and Dodge) shown in Table 2-5.

The application of the analysis weights in the study involved multiplying each imputed characteristic by the weight for unscreened or indeterminate facilities. In determining the total number of facilities in each subsector, each unscreened or indeterminate record was worth its respective analysis weight in the summation, while eligible facilities received a weight of 1 and ineligible facilities a weight of 0.

Table 2-6. Analysis weights for unscreened and indeterminate manufacturing facilities

NAICS and Subsector Manufacturing Type	Analysis Weight by Tier and Geography			
	Tier 1 Statewide	Tier 2 Statewide	Tier 3 Outside NYC	Tier 3 NYC
311 – Food	0.80	0.65	0.42	0.28
312 – Beverage and Tobacco Products	0.68	0.45	0.61	0.50
313 – Textile Mills	**0.78**	**0.70**	0.62	0.14
314 – Textile Product Mills	**0.78**	**0.70**	0.50	0.00
315 – Apparel	0.50	0.00	0.64	0.16
316 – Leather and Allied Products	**0.78**	**0.70**	0.86	0.25
321 – Wood Products	1.00	0.67	0.58	0.00
322 – Paper	0.87	0.73	0.78	0.00
323 – Printing and Related Support	0.33	0.86	0.67	0.33
324 – Petroleum and Coal Products	0.64	0.18	**0.67**	**0.26**
325 – Chemicals	0.65	0.82	0.77	0.08
326 – Plastics and Rubber Products	1.00	0.96	0.65	0.60
327 – Nonmetallic Mineral Products	0.88	0.85	0.68	0.56
331 – Primary Metals	0.84	0.88	0.80	0.00
332 – Fabricated Metal Products	1.00	1.00	0.82	0.42
333 – Machinery	0.80	0.86	0.69	0.30
334 – Computer and Electronic Products	0.81	0.71	0.63	0.18
335 – Electrical Equip., Appliances, and Components	1.00	0.88	0.71	0.20
336 – Transportation Equipment	0.93	0.76	0.60	0.00
337 – Furniture and Related Products	**0.78**	**0.70**	0.59	0.31
339 – Miscellaneous	0.75	0.69	0.72	0.24
Overall	**0.78**	**0.70**	**0.67**	**0.26**

2.5 Phase Two Metrics and Selection

A key output of this Phase One report is the selection of manufacturing subsectors for targeting in Phase Two. To facilitate this, the study team selected five key metrics for exploration at the subsector level from the results in this study. Weights were then established to balance the importance of each metric relative to one another and assess the impact of different weighting schemes on the subsectors available to target. The metrics selected for this exercise are the following, including the rationale for inclusion.

- ***Emissions*** is the primary target of CLCPA, important both for overall statewide climate change abatement and for environmental justice considerations.
- ***Consumption*** is the primary target of EE efforts.
- ***Employment*** is a key metric of industry economic value to the state, including total jobs provided.
- ***Value of Shipments*** is another key indicator of economic value to the state, and a measure of money coming in.

- ***Energy Expenditures*** is an indicator of business costs in the state related to energy. Expenditures also indicates how important energy management is to an industry. NYSERDA defines Tiers based on energy expenditures, which also indicates this metric is important across the agency.

The weights applied to each metric for Phase Two targeting selection are provided in Table 2-7. These were developed in consultation with NYSERDA and are used to provide the "Blended Metric Ranks" in each results table. Various weight combinations were tested as part of the process of determining the final weights and the selection of targeted subsectors changed very little in this exploration of alternative schemes. The purpose of providing this information in the result tables is to show the overall blended weighted metric rank alongside the values and ranks of each characteristic presented in the table (e.g., employees, number of facilities).

Table 2-7. Metric weights for selecting Phase Two targets

Metric	Weight
Total Consumption	0.15
Total Employment	0.1
Total Emissions	0.25
Total Value of Shipments	0.25
Total Energy Expenditures	0.25
Total	**1**

2.6 Disadvantaged Communities

The study team used a network analysis to evaluate the spatial relationships between the industrial facilities' addresses and disadvantaged communities (DACs) in New York State at the time of this report. Accordingly, DACs are:

- Located within census block groups that meet the HUD 50% AMI threshold, that are also located within the DEC Potential Environmental Justice Areas, or
- Located within New York State Opportunity Zones

Note that the New York State Opportunity Zones are at the tract level, and DEC Potential Environmental Justice Areas are at the tract level. However, because the first condition is at a mixed grain (census block group and census tract conditions), the analyses performed in this report and ensuing results are at the block group level.

A network analysis looks at the paths and connectivity between source and destination features – in this case, the industry points and the DACs – using a third data layer that represents the paths that can be

traveled and the costs accrued to the entity traveling these paths. The US Census TIGER road network was used for this analysis. TIGER is a national dataset that includes details on path distance as well as limitations on the path such as maximum travel speed and directional constraints. A key assumption of road-based network analysis is that the paths can only follow the road networks. While this assumption works well for vehicular travel, it is a representative approximation for foot traffic, given the reality that people may deviate from the road network under some circumstances (e.g., walk across a park or railroad tracks.

To conduct the network analysis, the study team first geocoded[25] the address strings of all manufacturing facilities. The team leveraged the New York State emergency system geolocator tool to place the addresses at the correct point in space. Not all addresses were successfully geocoded due to various factors including missing details, informal location names, and other challenges; for the NYSERDA network analysis, the team geocoded 20,661 records representing 87.9% of the overall population. For records that could not be geocoded, the team used third-party supplied latitude and longitude coordinates when they were provided. This resulted in an additional 2,275 records being placed for a final 22,936 records representing 97.5% of the overall population being placed into geographic space so it could be leveraged for the network analysis. Facilities identified in screening waves were left in the geocoded population file for comprehensiveness and identification purposes but are excluded in the geographic analysis presented in the report. This process reduced the final population from nearly 23,000 records to just over 19,000 screened records.

Once the locations were geocoded, the study team conducted three network analyses. These three were selected as they best characterize proximity by the transportation circumstances likely to be encountered by most New Yorkers:

1. **2.5 miles, one way.** This first distance range was set to correspond with the maximum one-way trip of 2.5 miles. An analysis of the 2009 National Household Travel Survey identified that trips under 2 miles make up 97% of all walking commutes in aggregate, and exceeded the median trip length for all income bins assessed.[26]
2. **10 miles, one way.** This distance range was set in consultation with NYSERDA on a useful result to provide.

[25] Geocoding is the process of taking a text string representing a physical location and converting it into a latitude and longitude coordinate so that the text string, and its associated data, can be visualized in the geographic space where it exists.

[26] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3377942/

3. **35 miles, one way.** This distance range was set to correspond with the maximum one-way trip of 35 miles. This represents over 92% of national one-way trips traveled from home to work per the Bureau of Transportation **Statistic's** Omnibus Survey data.[27]
4. **Within 1 mile of public transportation.** This final distance range was set to correspond with a maximum distance of one mile from the pre-calculated routes contained in the national transportation route database. This buffer approach was used to account for the following constraints:
    a. Lack of individual transit stop points,
    b. The overlapping nature of the routes, and
    c. The assumption that the individual using mass transit would be willing to traverse outward from the route to reach their final destination even if it was not directly off the narrow route path.

The team applied two analysis parameters to the 2.5-mile and 35-mile network analyses. They were:

- Adding a quarter-mile buffer to all roads in the network to capture points that are slightly off roads in rural areas.
- Using the centroid of each DAC as the starting point, which minimizes locational bias, but may under-capture the concentration of facilities within walking distance of DAC households.

The network analysis looked at several different relationships between DACs and manufacturing facilities, including:

1. **The nearest DAC for each block group, regardless of distance constraints.** This analysis serves to identify which facilities, industries, and associated employment are spatially isolated from the DACs.
2. **The raw number of facilities located within the 2.5 miles, 10 miles, 35 miles, or one mile of public transportation from each DAC block group's centroid.** This provides a quantification on the number of facilities, their industry subsector, and the total employment numbers by the different distances relative to the total number of residents of each DAC.

The emissions analysis uses a simple three-mile linear radius from each facility as a proxy to identify geographic areas that could be impacted by facility emissions. (This radius is consistent with that used in the energy Justice Screening Report for the Clean Power Plan Power Plan[28].) Overlapping facility emissions were added together to generate a total "all facilities" emissions impact on the geographic landscape. These results are provided in Section 3.5.2.

[27] https://www.nrc.gov/docs/ML1006/ML100621425.pdf, https://www.bts.gov/browse-statistical-products-and-data/statistical-products/surveys/household-survey

[28] https://19january2017snapshot.epa.gov/cleanpowerplan/ej-screening-report-clean-power-plan_.html

The DAC facility summary numbers were derived using a spatial intersection of each facility to the DAC block group geographies. Each facility was assigned the corresponding block group ID when the facility was identified as within the geographic boundaries of a block group; this in turn allowed the study team to aggregate and summarize the total number of facilities, the site-level consumption, and the site-level GHG emissions. These results are provided in Section 3.5.3.

2.7 Greenhouse Subsector Methods

The study team conducted a literature review for data resources and research for data on greenhouse facilities to support the calculation and imputation of performance metrics such as energy consumption and GHG emissions. This approach was performed concurrent with and in a similar fashion to the search for data sources discussed earlier. The scarcity of studies and data related directly to greenhouses was a challenge in obtaining these metrics. The existing data found was typically not directly relevant to greenhouses and was often geared towards specialized aspects of the agricultural industry. The search for greenhouse information sources identified and explored is discussed further below.

- **Greenhouse and nursery state license list:** This comprehensive listing of licensed nurseries and greenhouses in New York State provides a foundational dataset of locations with greenhouses present. Fields in the dataset include address, owner name, operation type (nursery, greenhouse, or both), size (glass square feet bins), and geo-reference. Because this list is regularly updated and is self-populated by greenhouse owners (and nurseries), it does not need to be screened beyond removing nursery facilities. The categorization of size (glass square feet ranges) is not conducive to granular scaling or imputation of information, because ranges do not provide a specific site-level value to impute from.
- **State-level agricultural baseline studies:** There is a lack of state-level agricultural baseline studies focused on greenhouses available to estimate baseline consumption metrics. Additionally, any agricultural datasets that do exist, such as US Agricultural Census data, do not offer enough granularity to filter down to greenhouses. These data sources tend to not have greenhouse-specific information and are geared more toward livestock and dairy production.
- **MA Cannabis Industry Standard Practice (ISP) Study:** DNV conducted an ISP (Industry Standard Practice) study[29] for technology used in the cannabis industry in Massachusetts. This report provides recommendations on currently existing cannabis-growing technologies (lighting, HVAC, and extraction equipment) appropriate for baseline use in energy impact calculations. A key limitation of this study is that the scope is limited to ISP baselines for cannabis-growing facilities, which may not be transferable directly to greenhouses.
- **Cornell.edu greenhouse modeling tool:** This tool is an open-source energy modeling platform, developed by students at Cornell University. The purpose of this tool is to input design parameters, which include greenhouse glass area, HVAC type, lighting, type of crop to grow, temperature and

[29] Massachusetts Cannabis Cultivation ISP, MA19C13-B-CANISP, Final Report, June 10, 2020

humidity setpoints, and many others, to produce an 8760-energy model simulation of that greenhouse. The tool outputs important energy consumption and emission metrics for the modeled greenhouse. While understanding consumption and emission metrics is of primary interest to this phase of work, exercising the model is dependent on inputs from greenhouse facilities on systems, efficiencies, facility design, etc. This tool will be considered as part of developing the Phase Two scope, where primary data collection will be performed and used to generate model outputs of interest. This tool was accompanied by a published report that has measured energy use and costs among other things for various buildings and rooms. The tool and report are available to run with building assumptions or with primary data collection as part of a Phase Two effort.

3 Results

All results in this report are specific to manufacturing facility either by explicit exclusion or by weighting. They use either direct data or inputs from data sources presented earlier and can be characterized into three broad categories of data. These broad categories are referred to throughout the results section to identify the type of data used.

- **NYS screened direct** refers to direct aggregation from the screened population, which are weighted to account for cases with unknown manufacturing status.
- **NYS screened imputed** refers to the calculation of results using the screened data with supplemental variables imputed based on MECS or economic census ratios to employment or Value of Shipments, applying NYS emissions factors, or other factors.
- **National** refers to summation of counts of other variables directly from MECS (not specific to NY). National results are provided for information that MECS does not provide at a finer geographic detail or where MECS census-division-level data has too many values suppressed to be useful. The Phase 2 analysis will obtain NYS-specific information for these topics.

In addition to this high-level guidance on data used in each results section, Appendix A provides the sources and detailed calculations used to generate the values in each table.

3.1 Industrial Firmographics

This section of the report presents the firmographics of the screened industrial population. They include the following by industrial subsector: number of manufacturing facilities, size (square feet), number of employees, and consumption (Btu). Following these key tables are consumption by square foot and location square feet per employee. Each table provides these estimates by tier to show how they vary by this key NYSERDA classification. This information provides an initial profile of manufacturing in New York State and trends by tier designation. These tables each represent manufacturing facilities in all of New York State as estimated after the screening and weighting process described above. Each table in this section is presented in alphabetical order by NAICS type with the accompanying NAICS code. Appendix A provides the sources and detailed calculations used to generate the values in each table.

3.1.1 Tier Classifications

Tiers based on energy expenditures are a key NYSERDA classification of industrial facilities. This section provides a detailed discussion of the process used to determine placement in tiers given its importance in characterizing results by subsector throughout this report. The tiers are defined as:

- **Tier 1:** Greater than $1M in annual energy expenditures.
- **Tier 2:** Between $500k and $1M in annual energy expenditures.

- **Tier 3:** Less than $500k in annual energy expenditures.

Equation 1 shows the method used to calculate the estimated annual energy expenditures for each manufacturing facility in the population to place each facility into an energy expenditure tier. Note that over the last year the dollars per Btu have increased substantially, suggesting that the number of facilities in each tier are conservative estimates. These expenditures per manufacturing facility were then aggregated by three-digit NAICS codes to estimate total sector and population expenditures. The team used MECS in lieu of census data for New York State because of the risk that the census data for a particular 31-33 NAICS code includes non-manufacturing industrial facilities in its consumption per employee values.

The variables in Equation 1 are defined as followed:

Variable	Definition	Source
$Number\ of\ Employees_i$	Number of employees for facility i	Data Axle, location employment size
$Establishment\ Weight_i$	Weight applied to manufacturing facility i as described in Section 2.4	Table 2-6
c	Index for each NAICS code	N/A
$Consumption\ per\ Employee_c$	Total energy consumption (MMBtus) per employee for NAICS code c	MECS Table 6.1
$Dollars\ per\ BTU_c$	MMBtu spent for NAICS code c	MECS Table 7.2

Equation 1. Calculation of Annual Facility Energy Expenditures

$$Annual\ Energy\ Expenditures_i = Number\ of\ Employees_i \times Establishment\ Weight_i \times Consumption\ per\ Employee_c \times Dollars\ per\ BTU_c$$

3.1.2 Size by Manufacturing Subsector

Table 3-1 presents the estimated number of manufacturing facilities by subsector and tier in New York State after the screening and weighting process described in Section 2. This table, and most others in the results section, includes the estimated value of interest (in this case, number of facilities) and a weighted rank to show the level of importance the subsector has based on the series of weighted metrics discussed in Section 2.4. There are an estimated 11,678 manufacturing facilities in New York State. Over 95% of these facilities are Tier 3, with annual energy expenditures less than $500,000. Apart from the Miscellaneous subsector, Fabricated Metals (332), Food (311), and Printing (323) are the three manufacturing subsectors with the greatest numbers of facilities. The manufacturing subsectors with the largest numbers of large facilities (Tier 1 and Tier 2) are Paper (322), Chemicals (325), Primary Metals

(331), Petroleum and Coal Products (324), and Nonmetallic Mineral Products (327). Nearly half of Paper (322) and Petroleum and Coal Products (324) facilities are in either Tier 1 or Tier 2.

The blended metric rank column here and in subsequent tables refers to the weighted average of ranks across five key sets of results along all subsectors including total emissions, consumption, employment, value of shipments, and energy expenditures, as described in Section 2.5. This differs from the sector rank, which shows the rank of each subsector for the result provided.

Table 3-1. NYS screened imputed number of manufacturing facilities by subsector and tier

NAICS and Subsector Manufacturing Type	Facilities (N)	% of total facilities	Sector rank	Tier			Blended Metric Rank
				1	2	3	
339 - Miscellaneous	2,087	18.9%	1	6	11	2,070	6.0
332 - Fabricated Metal Products	1,961	17.8%	2	6	14	1,941	6.8
311 - Food	1,228	11.1%	3	21	19	1,188	5.4
323 - Printing and Related Support	1,098	10.0%	4	2	6	1,090	13.3
333 - Machinery	692	6.3%	5	4	7	681	11.2
337 - Furniture and Related Products	688	6.2%	6	[a]	[a]	688	N/A
312 - Beverage and Tobacco Products	467	4.2%	7	15	10	442	10.6
334 - Computer and Electronic Products	435	3.9%	8	16	18	401	6.7
325 - Chemicals	328	3.0%	9	26	35	267	3.5
327 - Nonmetallic Mineral Products	304	2.8%	10	32	14	258	7.2
326 - Plastics and Rubber Products	239	2.2%	11	10	22	207	14.2
335 - Electrical Equip., Appliances, and Components	234	2.1%	12	3	7	224	14.3
321 - Wood Products	222	2.0%	13	2	2	218	14.4
336 - Transportation Equipment	218	2.0%	14	14	13	191	9.1
322 - Paper	213	1.9%	15	66	36	110	2.9
331 - Primary Metals	150	1.4%	16	31	24	95	5.6
314 - Textile Product Mills	110	1.0%	17	[a]	[a]	110	N/A
313 - Textile Mills	105	1.0%	18	[a]	[a]	105	N/A
315 - Apparel	103	0.9%	19	1	-	102	N/A
324 - Petroleum and Coal Products	98	0.9%	20	41	7	51	6.5
316 - Leather and Allied Products	41	0.4%	21	[a]	[a]	41	N/A
Total	**11,021**	**100.0%**	**N/A**	**296**	**245**	**10,480**	**N/A**

a Denotes instances where there was not enough information to impute a value.
Source: Calculated using 2018 MECS Table 3.2, Table 6.1, Table 7.6, Table 7.9, and Data Axle

The Miscellaneous subsector has the largest number of facilities, almost all of them Tier 3. It is not unusual in any classification scheme for a "remainder" category such as this to have many cases, particularly small ones. As shown in Table 3-2, this subsector ranks high also in terms of total employment and floor space, but not in terms of energy use. There is also little useful insight to be

gleaned related to Miscellaneous energy use patterns and practices. The discussion below therefore focuses on the non-Miscellaneous subsectors.

Table 3-2 presents the estimated number of employees in each subsector and tier in New York State. An estimated 317,501 employees work in manufacturing facilities across New York State. Apart from Miscellaneous, the three largest manufacturing subsectors by number of employees are Fabricated Metals (332), Computer and Electronic Products (334), and Machinery (333). Although Tier 1 is estimated to only have 2.7% of facilities in the state in Table 3-1, the size of the facilities in that tier raises the portion of employees in Tier 1 to be 37% of the total, while Tier 1 and Tier 2 combined have roughly half (49%) of the total manufacturing employment.

Table 3-2. NYS screened imputed number of employees by subsector and tier

NAICS and Subsector Manufacturing Type	Employees (N)	% of total employees	Sector rank	Tier			Blended Metric Rank
				1	2	3	
339 - Miscellaneous	46,822	15.1%	1	8,150	5,405	33,267	6.0
332 - Fabricated Metal Products	41,567	13.4%	2	3,724	4,239	33,604	6.8
334 - Computer and Electronic Products	35,101	11.3%	3	19,871	4,378	10,852	6.7
333 - Machinery	25,916	8.4%	4	4,883	3,250	17,783	11.2
311 - Food	23,789	7.7%	5	8,267	3,221	12,300	5.4
336 - Transportation Equipment	19,789	6.4%	6	14,370	2,389	3,030	9.1
325 - Chemicals	18,074	5.8%	7	11,815	2,558	3,701	3.5
327 - Nonmetallic Mineral Products	14,113	4.6%	8	10,355	837	2,921	7.2
335 - Electrical Equip., Appliances, and Components	12,579	4.1%	9	5,611	1,696	5,272	14.3
322 - Paper	11,899	3.8%	10	9,506	1,374	1,019	2.9
323 - Printing and Related Support	11,044	3.6%	11	1,000	1,150	8,894	13.3
326 - Plastics and Rubber Products	10,455	3.4%	12	3,928	2,629	3,899	14.2
312 - Beverage and Tobacco Products	10,294	3.3%	13	4,530	1,181	4,583	10.6
331 - Primary Metals	9,180	3.0%	14	7,464	868	848	5.6
337 - Furniture and Related Products	7,261	2.3%	15	[a]	[a]	7,261	N/A
321 - Wood Products	4,133	1.3%	16	730	375	3,028	14.4
315 - Apparel	2,597	0.8%	17	640	[a]	1,957	N/A
313 - Textile Mills	1,845	0.6%	18	[a]	[a]	1,845	N/A
324 - Petroleum and Coal Products	1,413	0.5%	19	1,241	41	130	6.5
314 - Textile Product Mills	1,269	0.4%	20	[a]	[a]	1,269	N/A
316 - Leather and Allied Products	910	0.3%	21	[a]	[a]	910	N/A
Total	**310,050**	**100.0%**	**N/A**	**116,085**	**35,591**	**158,373**	**N/A**

a Denotes instances where there was not enough information to impute a value.
Source: Calculated using 2018 MECS Table 3.2, Table 6.1, Table 7.6, Table 7.9, and Data Axle

Table 3-3 brings together the information from the previous two tables to show the estimated number of employees by manufacturing facility and tier. The average Tier 1 facility has 392 employees, with the

averages dropping to 146 and 15 for Tier 2 and Tier 3, respectively. The Transportation Equipment (336) subsector has the highest average employee count per facility at 91, followed by Computer and Electronics (334) with 81, Primary Metals (331) with 61, and Paper (322) with 56.

Table 3-3. NYS screened imputed number of employees per facility subsector and tier

NAICS and Subsector Manufacturing Type	Employees per facility	Sector rank	Tier			Blended Metric Rank
			1	2	3	
336 - Transportation Equipment	90.9	1	1,026.4	183.8	15.9	9.1
334 - Computer and Electronic Products	80.7	2	1,241.9	243.2	27.1	6.7
331 - Primary Metals	61.3	3	242.0	36.7	8.9	5.6
322 - Paper	55.9	4	144.3	37.7	9.2	2.9
325 - Chemicals	55.1	5	454.4	73.5	13.8	3.5
335 - Electrical Equip., Appliances, and Components	53.9	6	1,870.4	242.3	23.6	14.3
327 - Nonmetallic Mineral Products	46.4	7	323.6	60.5	11.3	7.2
326 - Plastics and Rubber Products	43.8	8	392.8	119.5	18.8	14.2
333 - Machinery	37.5	9	1,220.8	473.9	26.1	11.2
315 - Apparel	25.3	10	640.0	[a]	19.2	N/A
316 - Leather and Allied Products	22.5	11	[a]	[a]	22.5	N/A
339 - Miscellaneous	22.4	12	1,358.3	491.4	16.1	6.0
312 - Beverage and Tobacco Products	22.1	13	302.0	118.1	10.4	10.6
332 - Fabricated Metal Products	21.2	14	620.7	302.8	17.3	6.8
311 - Food	19.4	15	393.7	169.6	10.4	5.4
321 - Wood Products	18.6	16	365.0	187.5	13.9	14.4
313 - Textile Mills	17.6	17	[a]	[a]	17.6	N/A
324 - Petroleum and Coal Products	14.4	18	30.1	6.2	2.6	6.5
314 - Textile Product Mills	11.6	19	[a]	[a]	11.6	N/A
337 - Furniture and Related Products	10.6	20	[a]	[a]	10.6	N/A
323 - Printing and Related Support	10.1	21	500.0	191.7	8.2	13.3
Total	**28.1**		**392.3**	**145.7**	**15.1**	**N/A**

a Denotes instances where there was not enough information to impute a value.

Source: Calculated as ratio of Table 3-2 and Table 3-1

Table 3-4 shows total square feet by manufacturing subsector and tier. There is an estimated total of 300,028 thousand square feet in manufacturing facility space in the state. Roughly 42% of that space is in Tier 1 facilities and 11% in Tier 2. The largest four (non-Miscellaneous) manufacturing subsectors in this analysis represent just shy of 43% of the total manufacturing square feet estimated in the state (Fabricated Metals (332), Machinery (333), Paper (322), and Nonmetallic Mineral Products (327)).

Table 3-4. NYS screened imputed total square feet by subsector and tier (1,000)

NAICS and Subsector Manufacturing Type	Square feet (1,000)	% of total sq ft	Sector rank	Tier			Blended Metric Rank
				1	2	3	
332 - Fabricated Metal Products	43,057,764	14.4%	1	3,857,600	4,391,076	34,809,088	6.8
322 - Paper	41,512,223	13.8%	2	33,163,605	4,794,505	3,554,112	2.9
339 - Miscellaneous	27,057,113	9.0%	3	4,709,675	3,123,410	19,224,028	6.0
333 - Machinery	25,190,705	8.4%	4	4,746,372	3,158,647	17,285,686	11.2
327 - Nonmetallic Mineral Products	19,014,167	6.3%	5	13,950,746	1,127,571	3,935,850	7.2
334 - Computer and Electronic Products	17,937,944	6.0%	6	10,154,489	2,237,496	5,545,958	6.7
311 - Food	17,836,094	5.9%	7	6,198,487	2,415,275	9,222,332	5.4
336 - Transportation Equipment	16,147,310	5.4%	8	11,725,470	1,949,349	2,472,491	9.1
312 - Beverage and Tobacco Products	15,037,054	5.0%	9	6,617,347	1,725,185	6,694,522	10.6
331 - Primary Metals	12,788,582	4.3%	10	10,397,628	1,209,043	1,181,912	5.6
326 - Plastics and Rubber Products	12,409,137	4.1%	11	4,661,867	3,120,240	4,627,030	14.2
325 - Chemicals	11,408,810	3.8%	12	7,458,023	1,614,551	2,336,235	3.5
323 - Printing and Related Support	10,331,897	3.4%	13	935,553	1,075,885	8,320,459	13.3
321 - Wood Products	8,397,747	2.8%	14	1,483,365	762,002	6,152,380	14.4
335 - Electrical Equip., Appliances, and Components	7,030,486	2.3%	15	3,136,138	947,885	2,946,463	14.3
337 - Furniture and Related Products	6,556,175	2.2%	16	[a]	[a]	6,556,175	N/A
313 - Textile Mills	2,473,326	0.8%	17	[a]	[a]	2,473,326	N/A
324 - Petroleum and Coal Products	1,960,705	0.7%	18	1,722,369	57,229	181,107	6.5
315 - Apparel	1,783,480	0.6%	19	439,600	[a]	1,343,880	N/A
314 - Textile Product Mills	1,416,845	0.5%	20	[a]	[a]	1,416,845	N/A
316 - Leather and Allied Products	680,040	0.2%	21	[a]	[a]	680,040	N/A
Total	**300,027,604**	**100.0%**	**N/A**	**125,358,334**	**33,709,349**	**140,959,919**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated using 2018 MECS Table 3.2, Table 6.1, 9.1, and Data Axle

Table 3-5 shows square feet per facility by manufacturing subsector and tier. Paper (322) has the largest facilities when viewed by size this way, at an average 100,802 square feet per facility. Primary Metals (331), Transportation (336), and Nonmetallic Mineral Products (327) are the next largest subsectors, with 86,960, 67,928, and 56,398 average facility square feet, respectively. Tier 1 average facility size is 15 times larger than the overall state average at 366,145 square feet vs 24,321 square feet. Tier 3 facilities are about half the size of the overall average.

Table 3-5. NYS screened imputed square feet per facility by subsector and tier

NAICS and Subsector Manufacturing Type	Square feet per facility	Sector rank	Tier			Blended Metric Rank
			1	2	3	
322 - Paper	100,802	1	269,853	70,489	16,510	2.9
331 - Primary Metals	86,960	2	361,756	56,325	12,804	5.6
336 - Transportation Equipment	67,928	3	844,754	151,243	12,278	9.1
327 - Nonmetallic Mineral Products	56,398	4	406,822	79,006	14,599	7.2
326 - Plastics and Rubber Products	51,665	5	466,187	141,829	22,229	14.2
335 - Electrical Equip., Appliances, and Components	39,914	6	1,948,899	187,646	17,038	14.3
334 - Computer and Electronic Products	39,515	7	629,247	122,096	13,376	6.7
333 - Machinery	35,930	8	1,186,593	460,636	25,311	11.2
325 - Chemicals	35,652	9	281,460	48,345	9,039	3.5
312 - Beverage and Tobacco Products	29,155	10	396,293	158,780	13,675	10.6
321 - Wood Products	22,438	11	460,684	236,653	16,842	14.4
332 - Fabricated Metal Products	21,545	12	642,933	313,648	17,755	6.8
313 - Textile Mills	21,143	13	[a]	[a]	21,143	N/A
315 - Apparel	15,957	14	439,600	[a]	12,447	N/A
311 - Food	14,412	15	285,623	121,906	7,552	5.4
316 - Leather and Allied Products	14,330	16	[a]	[a]	14,330	N/A
324 - Petroleum and Coal Products	12,664	17	26,222	5,356	2,258	6.5
339 - Miscellaneous	12,353	18	797,814	288,601	8,981	6.0
314 - Textile Product Mills	12,087	19	[a]	[a]	12,087	N/A
323 - Printing and Related Support	9,133	20	429,315	176,326	7,341	13.3
337 - Furniture and Related Products	8,490	21	[a]	[a]	8,490	N/A
Total	**24,321**	**N/A**	**366,145**	**129,068**	**12,749**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated as ratio of Table 3-4 and Table 3-1

Table 3-6 shows energy expenditures by manufacturing subsector and tier. Paper (322) has the highest energy expenditures, at over $223 million. Petroleum and Coal Products (324), Chemicals (325), and Primary Metals (331) are the next largest subsectors, with $200,577 million, $175,649 million, and $167,538 million, respectively. Tier 1 expenditures account for roughly 60% of all energy expenditures in these subsectors.

Table 3-6. NYS screened imputed energy expenditures by subsector and tier

NAICS and Subsector Manufacturing Type	Energy Expenditures ($1,000)	Sector rank	Tier			Blended Metric Rank
			1	2	3	
322 - Paper	223,586	1	178,620	25,823	19,143	2.9
324 - Petroleum and Coal Products	200,577	2	176,195	5,854	18,527	6.5
325 - Chemicals	175,649	3	114,823	24,858	35,969	3.5
331 - Primary Metals	167,538	4	136,215	15,839	15,484	5.6
327 - Nonmetallic Mineral Products	165,654	5	121,541	9,824	34,290	7.2
311 - Food	107,618	6	37,400	14,573	55,645	5.4
334 - Computer and Electronic Products	89,976	7	50,934	11,223	27,818	6.7
332 - Fabricated Metal Products	89,765	8	8,042	9,154	72,568	6.8
336 - Transportation Equipment	72,127	9	52,375	8,707	11,044	9.1
339 - Miscellaneous	68,802	10	11,976	7,942	48,883	6.0
312 - Beverage and Tobacco Products	62,795	11	27,634	7,204	27,957	10.6
326 - Plastics and Rubber Products	56,693	12	21,298	14,255	21,139	14.2
323 - Printing and Related Support	38,156	13	3,455	3,973	30,727	13.3
333 - Machinery	35,768	14	6,739	4,485	24,544	11.2
335 - Electrical Equip., Appliances, and Components	34,875	15	15,557	4,702	14,616	14.3
321 - Wood Products	17,876	16	3,158	1,622	13,096	14.4
315 - Apparel	4,368	17	1,077	[a]	3,292	N/A
316 - Leather and Allied Products	910	18	[a]	[a]	910	N/A
313 - Textile Mills	[a]	N/A	[a]	[a]	[a]	N/A
314 - Textile Product Mills	[a]	N/A	[a]	[a]	[a]	N/A
337 - Furniture and Related Products	[a]	N/A	[a]	[a]	[a]	N/A
Total	**1,612,732**	**N/A**	**967,041**	**170,040**	**475,651**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated using 2018 MECS Table 3.2, Table 6.1, 7.6, 7.9 and Data Axle

3.1.3 Manufactured Products

The Economic Census collects value of shipments by manufactured product type for each NAICS code. Table 3-7 and Table 3-8 show the top 10 products by dollar value of shipment for the Paper (322) (Table 3-7) and Primary Metals (331) (Table 3-8) manufacturing subsectors. The remaining manufactured products for each subsector are categorized as Other. All other manufacturing subsectors are provided in Appendix F. In most manufacturing subsectors, the top three products in dollars shipped represent more than half of the subsector total. For the two subsectors displayed in Table 3-7 and Table 3-8, the top three manufactured products represent 65% of total dollars shipped for Paper (322) and 59% of Primary Metals (331).

Table 3-7. National 322 Paper top 10 manufactured products

Manufactured product	% of total 3-digit NAICS dollar shipments
Boxes, crates, tubes, drums, and similar packaging, packing, and shipping products	29.7%
Paperboard products	18.8%
Miscellaneous packaging and packing products	16.2%
Paper, except printing paper	10.5%
Household paper products, except tableware	6.2%
Pulp	4.7%
Paper office and school supplies	3.5%
Miscellaneous materials and supplies for services, nec.	1.6%
Flexible packaging roll and sheet products	1.5%
Bag, pouch, and liner products	1.4%
Other	5.9%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

Table 3-8. National 331 Primary Metals top 10 manufactured products

Manufactured product	% of total 3-digit NAICS dollar shipments
Iron and steel in primary and mill shapes, except pipe and tube	34.4%
Primary, secondary, and alloyed aluminum in primary and mill shapes, except pipe and tube	12.5%
Metal castings	12.2%
Other primary, secondary, and alloyed nonferrous metals in primary and mill shapes, except wire, pipe, and tube	9.4%
Primary, secondary, and alloyed copper in primary and mill shapes, except pipe and tube	6.8%
Structural metal, brick, block, and dimension stone, and structural wood used for construction	6.5%
Nonferrous wire, cord, and cable products	5.1%
Metal pipe and tube, except copper plumbing pipe and cast-iron pipe	3.7%
Ferroalloys and miscellaneous materials and supplies for primary metals manufacturing	3.7%
Coke oven and blast furnace products, except slag	1.0%
Other	4.6%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

3.2 Consumption

Table 3-9 shows consumption (MMBtu) overall and by manufacturing subsector and tier. The consumption reflected here is the total direct energy consumption used as a fuel at the facility (not including feedstocks). Manufacturing facilities are estimated to consume 166 trillion Btu of energy overall in New York State. Facilities in Tier 1 represent 66% of total manufacturing consumption, with an estimate of 110 trillion Btu. Tier 3 represents 24% of total consumption. The Paper (322) subsector has

the greatest consumption at 45 trillion Btu, followed by Petroleum and Coal Products (324), Primary Metals (331), and Nonmetallic Mineral Products (327).

Table 3-9. NYS screened imputed total consumption in MMBtu by subsector and tier

NAICS and Subsector Manufacturing Type	Overall Energy Consumption (MMBtu)	Electric Consumption (MMBtu)	Natural Gas Consumption (MMBtu)	Other Consumption (MMBtu)	% of total consumption	Sector rank	Tier			Blended Metric Rank
							1	2	3	
322 – Paper	45,047,478	3,537,760	18,160,502	23,349,216	27.2%	1	35,987,877	5,202,814	3,856,787	2.9
324 - Petroleum and Coal Products	19,446,149	1,100,725	5,136,719	13,208,705	11.7%	2	17,082,350	567,596	1,796,203	6.5
331 - Primary Metals	18,861,941	3,421,038	6,657,155	8,783,747	11.4%	3	15,335,510	1,783,223	1,743,207	5.6
327 - Nonmetallic Mineral Products	18,584,453	2,982,690	11,930,760	3,671,003	11.2%	4	13,635,464	1,102,088	3,846,901	7.2
325 – Chemicals	18,178,927	4,574,829	11,437,073	2,167,025	11.0%	5	11,883,699	2,572,644	3,722,584	3.5
311 – Food	8,554,515	2,851,505	5,069,342	633,668	5.2%	6	2,972,907	1,158,410	4,423,198	5.4
332 - Fabricated Metal Products	5,490,940	2,506,734	2,864,839	119,368	3.3%	7	491,940	559,972	4,439,028	6.8
336 - Transportation Equipment	5,273,803	[a]	2,636,902	2,636,901	3.2%	8	3,829,605	636,669	807,530	9.1
339 – Miscellaneous	4,551,079	1,873,974	2,409,395	267,710	2.7%	9	792,180	525,366	3,233,533	6.0
312 - Beverage and Tobacco Products	4,229,735	1,952,185	2,277,550	0	2.6%	10	1,861,377	485,273	1,883,085	10.6
334 - Computer and Electronic Products	4,057,729	2,646,345	1,411,384	0	2.4%	11	2,297,040	506,142	1,254,547	6.7
321 - Wood Products	3,809,557	366,304	366,304	3,076,950	2.3%	12	672,914	345,675	2,790,968	14.4
326 - Plastics and Rubber Products	3,307,069	1,889,754	1,299,206	118,109	2.0%	13	1,242,400	831,553	1,233,116	14.2
335 - Electrical Equip., Appliances, and Components	2,405,156	1,002,148	1,403,008	0	1.5%	14	1,072,885	324,275	1,007,996	14.3
333 – Machinery	1,847,799	1,055,885	659,928	131,985	1.1%	15	348,158	231,694	1,267,947	11.2
323 - Printing and Related Support	1,797,903	998,835	599,301	199,767	1.1%	16	162,800	187,220	1,447,883	13.3
315 – Apparel	182,016	[a]	[a]	182,016	0.1%	17	44,864	[a]	137,152	N/A
316 - Leather and Allied Products	101,121	[a]	[a]	101,121	0.1%	18	[a]	[a]	101,121	N/A
313 - Textile Mills	[a]	[a]	[a]	[a]	[a]	N/A	[a]	[a]	[a]	N/A
314 - Textile Product Mills	[a]	[a]	[a]	[a]	[a]	N/A	[a]	[a]	[a]	N/A
337 - Furniture and Related Products	[a]	[a]	[a]	[a]	[a]	N/A	[a]	[a]	[a]	N/A
Total	**165,727,370**	**32,760,712**	**74,319,366**	**58,647,291**	**100.0%**	**N/A**	**109,713,970**	**17,020,614**	**38,992,786**	**N/A**

a Denotes instances where there was not enough information to impute a value
Calculated using 2018 MECS Table 3.2, Table 6.1, and Data Axle

Table 3-10 shows average consumption per facility (MMBtu) overall and by manufacturing subsector and tier. The average manufacturing facility in New York State consumes 15,040 MMBtu of energy. Tier 1 facilities use much larger amounts of energy, with an average of 370,734 MMBtu, while Tier 2 facilities use an average of 69,669 MMBtu. By a wide margin, the three subsectors with the highest average energy consumption per facility in New York State are Paper (322), Petroleum and Coal Products (324), and Primary Metals (331).

Table 3-10. NYS screened imputed consumption per facility in MMBtu by subsector and tier

NAICS and Subsector Manufacturing Type	Consumption (MMBtu) per Facility	Sector rank	Tier			Blended Metric Rank
			1	2	3	
322 - Paper	211,713	1	546,320	142,706	34,921	2.9
324 - Petroleum and Coal Products	197,566	2	414,416	84,641	35,567	6.5
331 - Primary Metals	126,025	3	497,200	75,480	18,311	5.6
327 - Nonmetallic Mineral Products	61,083	4	426,108	79,595	14,887	7.2
325 - Chemicals	55,386	5	457,065	73,893	13,921	3.5
336 - Transportation Equipment	24,236	6	273,543	48,975	4,237	9.1
321 - Wood Products	17,140	7	336,457	172,838	12,787	14.4
326 - Plastics and Rubber Products	13,840	8	124,240	37,798	5,959	14.2
335 - Electrical Equip., Appliances, and Components	10,297	9	357,628	46,325	4,509	14.3
334 - Computer and Electronic Products	9,333	10	143,565	28,119	3,130	6.7
312 - Beverage and Tobacco Products	9,061	11	124,092	48,527	4,262	10.6
311 - Food	6,967	12	141,567	60,969	3,723	5.4
332 - Fabricated Metal Products	2,800	13	81,990	39,998	2,287	6.8
333 - Machinery	2,671	14	87,039	33,789	1,862	11.2
316 - Leather and Allied Products	2,497	15	[a]	[a]	2,497	N/A
339 - Miscellaneous	2,180	16	132,030	47,761	1,562	6.0
315 - Apparel	1,771	17	44,864	a	1,347	N/A
323 - Printing and Related Support	1,637	18	81,400	31,203	1,328	13.3
313 - Textile Mills	[a]	N/A	[a]	[a]	[a]	N/A
314 - Textile Product Mills	[a]	N/A	[a]	[a]	[a]	N/A
337 - Furniture and Related Products	[a]	N/A	[a]	[a]	[a]	N/A
Overall	**15,040**	**N/A**	**370,734**	**69,669**	**3,721**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated as ratio of Table 3-9 and Table 3-1

Table 3-11 shows average direct energy consumption (MMBtu) per employee overall and by manufacturing subsector. Tier-level results are not provided in this table or the next because the imputation method for this characteristic uses the same factors within an industry sector regardless of size, so the normalized values by tier are the same. The average consumption per manufacturing employee is 534.5 MMBtu. Petroleum and Coal Products (324) has the highest rate of energy

consumption at 13,764 MMBtu per employee, followed by Paper (322), Primary Metals (331), and Nonmetallic Mineral Products (327).

Table 3-11. NYS screened imputed consumption per employee in MMBtu

NAICS and Subsector Manufacturing Type	Consumption (MMBtu) per Employee	Sector rank	Blended Metric Rank
324 - Petroleum and Coal Products	13,764.8	1	6.5
322 - Paper	3,785.7	2	2.9
331 - Primary Metals	2,054.7	3	5.6
327 - Nonmetallic Mineral Products	1,316.8	4	7.2
325 - Chemicals	1,005.8	5	3.5
321 - Wood Products	921.8	6	14.4
312 - Beverage and Tobacco Products	410.9	7	10.6
311 - Food	359.6	8	5.4
326 - Plastics and Rubber Products	316.3	9	14.2
336 - Transportation Equipment	266.5	10	9.1
335 - Electrical Equip., Appliances, and Components	191.2	11	14.3
323 - Printing and Related Support	162.8	12	13.3
332 - Fabricated Metal Products	132.1	13	6.8
334 - Computer and Electronic Products	115.6	14	6.7
316 - Leather and Allied Products	111.1	15	N/A
339 - Miscellaneous	97.2	16	6.0
333 - Machinery	71.3	17	11.2
315 - Apparel	70.1	18	N/A
313 - Textile Mills	[a]	N/A	N/A
314 - Textile Product Mills	[a]	N/A	N/A
337 - Furniture and Related Products	[a]	N/A	N/A
Overall	**534.5**	**N/A**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated as ratio of Table 3-9 and Table 3-1

Table 3-12 shows average direct energy consumption (MMBtu) per square foot overall and by manufacturing subsector. The greater the consumption per square foot, the greater the energy intensity of that subsector. The average consumption per manufacturing square foot is 0.55 MMBtu. Petroleum and Coal Products (324) has the highest rate of energy consumption at 9.92 MMBtu per square foot, followed by Chemicals (325), Primary Metals (331), and Paper (322).

Table 3-12. NYS screened imputed consumption per square foot in MMBtu

NAICS and Subsector Manufacturing Type	Consumption (MMBtu) per Square Foot	Sector rank	Blended Metric rank
324 - Petroleum and Coal Products	9.92	1	6.5
325 - Chemicals	1.59	2	3.5
331 - Primary Metals	1.47	3	5.6
322 - Paper	1.09	4	2.9
327 - Nonmetallic Mineral Products	0.98	5	7.2
311 - Food	0.48	6	5.4
321 - Wood Products	0.45	7	14.4
335 - Electrical Equip., Appliances, and Components	0.34	8	14.3
336 - Transportation Equipment	0.33	9	9.1
312 - Beverage and Tobacco Products	0.28	10	10.6
326 - Plastics and Rubber Products	0.27	11	14.2
334 - Computer and Electronic Products	0.23	12	6.7
323 - Printing and Related Support	0.17	13	13.3
339 - Miscellaneous	0.17	13	6.0
316 - Leather and Allied Products	0.15	15	N/A
332 - Fabricated Metal Products	0.13	16	6.8
315 - Apparel	0.10	17	N/A
333 - Machinery	0.07	18	11.2
313 - Textile Mills	[a]	N/A	N/A
314 - Textile Product Mills	[a]	N/A	N/A
337 - Furniture and Related Products	[a]	N/A	N/A
Overall	**0.55**	**N/A**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated as ratio of Table 3-9 and Table 3-1

Table 3-13 shows total dollar value of shipments overall, by manufacturing subsector and tier. Overall, there is an estimated $103.45 billion in value of shipments from manufacturers in New York State, 46% of which was from facilities in Tier 1. The largest manufacturing subsectors in value of shipments are Chemicals (325), Computer and Electronic Products (334), and Food (311).

Table 3-13. NYS screened imputed total dollar value of shipments by subsector and tier

NAICS and Subsector Manufacturing Type	Total $ Value of Shipments ($1,000)	% of total $	Sector rank	Tier			Blended Metric Rank
				1	2	3	
339 - Miscellaneous	15,170,265	14.7%	1	2,640,600	1,751,220	10,778,445	6.0
325 - Chemicals	12,119,285	11.7%	2	7,922,466	1,715,096	2,481,723	3.5
334 - Computer and Electronic Products	10,144,323	9.8%	3	5,742,599	1,265,356	3,136,368	6.7
311 - Food	9,505,016	9.2%	4	3,303,230	1,287,122	4,914,664	5.4
322 - Paper	8,044,193	7.8%	5	6,426,407	929,074	688,712	2.9
332 - Fabricated Metal Products	7,844,201	7.6%	6	702,772	799,960	6,341,469	6.8
336 - Transportation Equipment	7,534,004	7.3%	7	5,470,864	909,526	1,153,614	9.1
333 - Machinery	6,159,332	6.0%	8	1,160,526	772,315	4,226,490	11.2
331 - Primary Metals	4,715,485	4.6%	9	3,833,878	445,806	435,802	5.6
312 - Beverage and Tobacco Products	4,229,735	4.1%	10	1,861,377	485,273	1,883,085	10.6
324 - Petroleum and Coal Products	4,227,424	4.1%	11	3,713,554	123,390	390,479	6.5
323 - Printing and Related Support	3,595,806	3.5%	12	325,600	374,440	2,895,766	13.3
327 - Nonmetallic Mineral Products	3,573,933	3.5%	13	2,622,205	211,940	739,789	7.2
335 - Electrical Equip., Appliances, and Components	3,435,937	3.3%	14	1,532,692	463,250	1,439,994	14.3
326 - Plastics and Rubber Products	2,204,713	2.1%	15	828,267	554,368	822,078	14.2
321 - Wood Products	777,461	0.8%	16	137,329	70,546	569,585	14.4
316 - Leather and Allied Products	168,535	0.2%	17	[a]	[a]	168,535	N/A
313 - Textile Mills	[a]	[a]	N/A	[a]	[a]	[a]	N/A
314 - Textile Product Mills	[a]	[a]	N/A	[a]	[a]	[a]	N/A
315 - Apparel	[a]	[a]	N/A	[a]	[a]	[a]	N/A
337 - Furniture and Related Products	[a]	[a]	N/A	[a]	[a]	[a]	N/A
Total	**103,449,647**	**100.0%**	**N/A**	**48,224,366**	**12,158,683**	**43,066,598**	**N/A**

a Denotes instances where there was not enough information to impute a value.

Source: Calculated using 2018 MECS Table 3.2, Table 6.1, and Data Axle

Table 3-14 shows consumption (thousands of Btu) per total dollar value of shipments overall and by manufacturing subsector. The higher the value, the more energy an industry needs per unit of product revenue. The ranking in this table goes from highest to lowest energy intensity. The thousand Btu per dollar value of shipments across all manufacturing subsectors is 1.6. The highest consumption per dollar value of shipments is in the Paper (322) manufacturing subsector, with an estimate of 5.6 thousand Btu/$, and the lowest is Machinery (333), with 0.30 thousand Btu/$.

Table 3-14. NYS screened imputed consumption (thousand Btu) per total dollar value of shipments

NAICS and Subsector Manufacturing Type	Consumption (kBtu) per $ Value of Shipments	Sector rank	Blended Metric Rank
322 - Paper	5.60	1	2.9
327 - Nonmetallic Mineral Products	5.20	2	7.2
321 - Wood Products	4.90	3	14.4
324 - Petroleum and Coal Products	4.60	4	6.5
331 - Primary Metals	4.00	5	5.6
325 - Chemicals	1.50	6	3.5
326 - Plastics and Rubber Products	1.50	7	14.2
312 - Beverage and Tobacco Products	1.00	8	10.6
311 - Food	0.90	9	5.4
332 - Fabricated Metal Products	0.70	10	6.8
336 - Transportation Equipment	0.70	11	9.1
335 - Electrical Equip., Appliances, and Components	0.70	12	14.3
316 - Leather and Allied Products	0.60	13	N/A
323 - Printing and Related Support	0.50	14	13.3
334 - Computer and Electronic Products	0.40	15	6.7
339 - Miscellaneous	0.30	16	6.0
333 - Machinery	0.30	17	11.2
313 - Textile Mills	a	N/A	N/A
314 - Textile Product Mills	a	N/A	N/A
315 - Apparel	a	N/A	N/A
337 - Furniture and Related Products	a	N/A	N/A
Overall	**1.60**	**N/A**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated as ratio of Table 3-9 and Table 3-13, with consumption scaled from MMBtu to kBtu

3.3 Equipment

This section of the report has four subsections regarding energy-consuming equipment (including energy efficient equipment), renewable energy generation, and energy storage.

3.3.1 Production/Process Equipment

Process and other production equipment often represent the most intensive energy consumption at a manufacturing facility.

Table 3-15 presents energy consumption by end use, fuel type, and tier. Overall, machine drives, facility HVAC, and process heating comprise the top three most electricity-consuming end uses and represents 72% of electric use in manufacturing facilities. Process heating is the primary driver of gas use overall, representing 46% of total gas consumption. CHP and/or cogeneration processes and conventional boilers

are the second- and third-greatest gas-consuming end uses, with 26% and 11% of overall consumption, respectively. Further data collection on the equipment and processes in these areas will be prime candidates for focus in Phase Two of this study.

Table 3-15 provides end use details for all manufacturing subsectors. Additional information is provided in Appendix E for eight[30] key industrial subsectors identified as among the largest manufacturer subsectors in the state based on total consumption, energy expenditures, and other energy-related metrics. These eight subsectors are likely candidates for targeting in the primary research in Phase Two. In this regard, the Phase Two data collection will consider those processes presented in this section for direct observation and deeper examination.

[30] Primary Metals (331), Pulp and Paper (322), Chemicals manufacturing (325), Food manufacturing (311), Nonmetallic Minerals (327), Computers and Electronics (334), Fabricated Metals (332), and Plastics and Rubber Products (326).

Table 3-15. NYS screened imputed energy consumption by end use, fuel type, and tier

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	67,413,083	[a]	[a]	[a]	[a]	[a]	[a]	49,944,012	6,207,830	11,261,241
Conventional Boiler Use	361,349	6,915,810	[a]	206,312	42,687	112,350	4,320,446	817,484	1,777,881	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	16,549,868	[a]	0	0	0	11,132,622	1,956,580	3,460,667	[a]	[a]	[a]
Process Heating	4,114,571	29,388,690	[a]	2,463,819	450,708	1,200,044	19,657,246	2,763,199	6,968,245	[a]	[a]	[a]
Process Cooling and Refrigeration	2,810,824	212,464	[a]	1,354,747	357,599	1,098,478	144,299	21,371	46,794	[a]	[a]	[a]
Machine Drive	16,729,718	1,636,234	[a]	9,211,856	1,928,133	5,589,729	1,029,672	161,145	445,416	[a]	[a]	[a]
Electro-Chemical Processes	1,464,760	[a]	[a]	1,111,899	153,615	199,246	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	1,096,490	1,766,773	[a]	659,573	126,758	310,160	1,205,084	205,415	356,274	[a]	[a]	[a]
Facility HVAC	4,201,298	5,979,249	[a]	1,860,893	510,144	1,830,261	2,831,396	713,797	2,434,055	[a]	[a]	[a]
Facility Lighting	2,595,318	[a]	[a]	1,179,464	316,538	1,099,316	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	787,980	559,439	[a]	376,244	97,989	313,746	280,885	68,019	210,535	[a]	[a]	[a]
Onsite Transportation	187,700	0	[a]	90,222	25,478	71,999	0	0	0	[a]	[a]	[a]
Conventional Electricity Generation	[a]	247,909	[a]	[a]	[a]	[a]	206,157	19,212	22,540	[a]	[a]	[a]
Other Nonprocess Use	104,736	129,277	[a]	67,665	11,403	25,668	84,436	13,243	31,598	[a]	[a]	[a]
End Use Not Reported	243,191	230,641	[a]	136,567	29,359	77,264	158,453	22,906	49,282	[a]	[a]	[a]
Total	34,697,934	63,616,353	67,413,083	18,719,262	4,050,412	11,928,260	41,050,696	6,762,371	15,803,286	49,944,012	6,207,830	11,261,241

a Denotes instances where there was not enough information to impute a value
Calculated using 2018 MECS Table 3.2, Table 6.1, Table 5.2, and Data Axle

3.3.2 Penetration of Energy-Efficient Equipment

System retrofit activity for efficiency purposes and the source of assistance (i.e., financial incentives, rebates, manufacturer markdowns) is tracked at the national level in the MECS national survey sample. Table 3-16 shows the source of assistance provided to all manufacturing establishments (NAICS 311-339) that reported undertaking a retrofit to improve the efficiency of a specific building system at the national level. These results were calculated from the MECS reported number of participating establishments as a percent of total establishments. The first column shows the system retrofit, the second shows the overall percent of facilities that reported a retrofit of that system type for efficiency purposes, and the remaining columns show the source of assistance they received to implement the retrofit. The largest portion of retrofits are done in-house, particularly for retrofits related to facility lighting and HVAC. Systems and processes that are unique to a manufacturing facility and product may be most confidently delivered through in-house specification and oversight.

Table 3-16. National retrofit activities and source of assistance (all manufacturing categories)

Retrofit for primary purpose of improving efficiency of…	Percent of Facilities	Source of Assistance					
		In-House	Utility/ Energy Supplier	Product/ Service Provider	Federal Program	State/ Local Program	Don't Know
Facility Lighting	31%	20%	5%	8%	<1%	1%	3%
Facility HVAC	27%	15%	1%	12%	<1%	<1%	3%
Compressed Air Systems	15%	10%	1%	5%	<1%	<1%	1%
Direct Machine Drive	14%	10%	1%	4%	<1%	<1%	<1%
Direct/Indirect Process Heating	12%	7%	1%	5%	<1%	<1%	<1%
Direct Process Cooling, Refrigeration	8%	4%	1%	3%	<1%	<1%	<1%
Steam Production/Systems	5%	3%	<1%	2%	<1%	<1%	<1%

Source: Calculated from 2018 MECS Table 8.1

Table 3-17 shows retrofit activity by industrial NAICS code and affected system at the national level. Activity reported to be greater than 20% in a manufacturing subsector has an asterisk. Many industrial subsectors have made facility HVAC and facility lighting efficiency improvements, as observed in the last two columns. The process-related retrofits in the first five columns are less common but do have pockets of greater frequency within some NAICS codes. Higher levels of retrofit activity among process-related systems are seen in the Chemicals (325), Paper and Pulp (322), Plastics (326), Primary Metals (331), and Electric Equipment (335) NAICS codes. Of all retrofits reported, the most common process-related ones are compressed air (~16%), direct machine drives (~16%), and direct/indirect process heating (~13%).

Table 3-17. National energy management and retrofit activity by NAICS code

NAICS and Subsector Name	Retrofit for primary purpose of improving efficiency of…						
	Steam Production/ System	Compressed Air Systems	Direct/ Indirect Process Heating	Direct Process Cooling, Refrigeration	Direct Machine Drive	Facility HVAC	Facility Lighting
315 - Apparel	[a]	[a]	[a]	[a]	[a]	27%*	36%*
312 - Beverage & Tobacco Product	9%	13%	12%	21%*	15%	32%*	33%*
325 - Chemicals	15%	22%*	17%	15%	25%*	34%*	41%*
334 - Computer & Electronic Products	3%	17%	10%	8%	8%	42%*	36%*
335 - Electrical Equip, Appliance, & Component	7%	26%*	22%	14%	24%*	41%*	44%*
332 - Fabricated Metal Product	2%	13%	14%	4%	12%	22%*	30%*
311 - Food	13%	16%	15%	16%	17%	27%*	32%*
337- Furniture & Related Product	[a]	17%	10%	5%	11%	22%*	26%*
316 - Leather & Allied Product	3%	5%	6%	2%	7%	16%	21%*
333 - Machinery	2%	14%	11%	8%	12%	31%*	38%*
339 - Miscellaneous Mfg	3%	9%	8%	4%	5%	20%*	28%*
327 - Nonmetallic Mineral Products	4%	12%	10%	5%	13%	17%	21%*
322 - Paper and Pulp	10%	25%*	10%	8%	21%*	30%*	30%*
324 - Petroleum & Coal Products	11%	12%	21%*	7%	24%*	20%*	25%*
326 - Plastics & Rubber Products	3%	18%	15%	14%	21%*	39%*	41%*
331 - Primary Metals	4%	23%*	25%*	9%	25%*	31%*	38%*
323 - Printing & Related Support Activities	2%	12%	7%	2%	6%	30%*	24%*
313 - Textile Mills	9%	19%	15%	7%	21%*	32%*	31%*
314 - Textile Product Mills	[a]	15%	[a]	[a]	15%	31%*	30%*
336 - Transportation Equipment	5%	24%*	10%	8%	17%	35%*	38%*
321 - Wood Product	4%	18%	9%	2%	19%	18%	26%*
Percent of Total	4%	14%	11%	7%	12%	24%	28%
Total facilities engaged in retrofit activity	**8,013**	**27,084**	**20,968**	**13,132**	**24,707**	**48,771**	**56,840**

a Denotes instances where there was not enough information to impute a value
Source: Calculated from 2018 MECS Table 8.1

3.3.3 Onsite Renewable Electricity Generation and Storage

Table 3-18 shows the estimated total amount of renewable electricity generated onsite by manufacturing subsector. The second and third columns show total and electric consumption, and the fourth shows onsite renewable generation. Onsite renewables generation in this table does not include biomass or co-generation. Among the subsectors for which the team was able to impute an onsite renewables value (8 out of 21), Paper (322) accounts for 86% of onsite renewable generation, with Nonmetallic Mineral Products (327) and Food (311) in distant second and third. However, this is likely an incomplete view of the distribution of industrial onsite renewables generation. Based on MECS Table 11.3, which was used to impute the renewables generation quantities, the paper subsector only accounts for about 50% of total onsite renewable generation in the northeast, when subsectors masked by MECS are included in the denominator. Therefore, when able to impute onsite generation for the 13 subsectors currently masked, one would expect paper's weighted renewables generation to account for 50%-60% of total generation, still by far the largest contributor, as opposed to 87%. Overall, less than half a percent of manufacturing electric consumption is provided by onsite renewables.

Table 3-18. NYS screened imputed total and manufacturing subsector onsite renewable electricity generation, excluding biomass

NAICS and Subsector Manufacturing Type	Total Consumption (MMBtu)	Electric Consumption (MMBtu)	Onsite Renewables Generation (MMBtu)	Renewables as percent of subsector total consumption	Renewables as percent of subsector electric consumption	Subsector percent of total onsite generation	Sub-sector rank	Blended Metric Rank
322 - Paper	45,047,478	3,537,760	123,810	0.27%	3.50%	86.44%	1	2.9
327 - Nonmetallic Mineral Products	18,584,453	2,982,690	8,467	0.05%	0.28%	5.91%	2	7.2
311 - Food	8,554,515	2,851,505	7,281	0.09%	0.26%	5.08%	3	5.4
333 - Machinery	1,847,799	1,055,885	1,428	0.08%	0.14%	1.00%	4	11.2
331 - Primary Metals	18,861,941	3,421,038	940	0.00%	0.03%	0.66%	5	5.6
325 - Chemicals	18,178,927	4,574,829	811	0.00%	0.02%	0.57%	6	3.5
321 - Wood Products	3,809,557	366,304	493	0.01%	0.13%	0.34%	7	14.4
324 - Petroleum and Coal Products	19,446,149	1,100,725	[a]	0.00%	0.00%	0.00%	8	6.5
332 - Fabricated Metal Products	5,490,940	2,506,734	[a]	[a]	[a]	[a]	N/A	6.8
336 - Transportation Equipment	5,273,803	[a]	[a]	[a]	[a]	[a]	N/A	9.1
339 - Miscellaneous	4,551,079	1,873,974	[a]	[a]	[a]	[a]	N/A	6.0
312 - Beverage and Tobacco Products	4,229,735	1,952,185	[a]	[a]	[a]	[a]	N/A	10.6
334 - Computer and Electronic Products	4,057,729	2,646,345	[a]	[a]	[a]	[a]	N/A	6.7
326 - Plastics and Rubber Products	3,307,069	1,889,754	[a]	[a]	[a]	[a]	N/A	14.2
335 - Electrical Equip., Appliances, and Components	2,405,156	1,002,148	[a]	[a]	[a]	[a]	N/A	14.3
323 - Printing and Related Support	1,797,903	998,835	[a]	[a]	[a]	[a]	N/A	13.3
315 - Apparel	182,016	[a]	[a]	[a]	[a]	[a]	N/A	N/A
316 - Leather and Allied Products	101,121	[a]	[a]	[a]	[a]	[a]	N/A	N/A
313 - Textile Mills	[a]	[a]	[a]	[a]	[a]	[a]	N/A	N/A
314 - Textile Product Mills	[a]	[a]	[a]	[a]	[a]	[a]	N/A	N/A
337 - Furniture and Related Products	[a]	[a]	[a]	[a]	[a]	[a]	N/A	N/A
Total	**165,727,371**	**32,760,712**	**143,230**	**0.51%**	**4.35%**	**100.00%**	**N/A**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated using 2018 MECS Table 3.2, Table 6.1, Table 11.1, Table 11.3 and Data Axle

Table 3-19 presents onsite renewables by manufacturing subsector and tier. Just over 76% of onsite renewable generation are in Tier 1 facilities, driven by 90% of Tier 1 onsite renewables in the Paper (322) manufacturing subsector.

Table 3-19. NYS screened imputed manufacturing subsector and tier onsite renewable electricity generation, excluding biomass

NAICS and Subsector Manufacturing Type	Onsite Renewables Generation (MMBtu)	Onsite Generation (MMBtu) by Tier			Blended Metric Rank
		1	2	3	
322 - Paper	123,810	98,910	14,300	10,600	2.9
327 - Nonmetallic Mineral Products	8,467	6,212	502	1,753	7.2
311 - Food	7,281	2,530	986	3,765	5.4
333 - Machinery	1,428	269	179	980	11.2
331 - Primary Metals	940	764	89	87	5.6
325 - Chemicals	811	530	115	166	3.5
321 - Wood Products	493	87	45	361	14.4
324 - Petroleum and Coal Products	[a]	[a]	[a]	[a]	6.5
332 - Fabricated Metal Products	[a]	[a]	[a]	[a]	6.8
336 - Transportation Equipment	[a]	[a]	[a]	[a]	9.1
339 - Miscellaneous	[a]	[a]	[a]	[a]	6.0
312 - Beverage and Tobacco Products	[a]	[a]	[a]	[a]	10.6
334 - Computer and Electronic Products	[a]	[a]	[a]	[a]	6.7
326 - Plastics and Rubber Products	[a]	[a]	[a]	[a]	14.2
335 - Electrical Equip., Appliances, and Components	[a]	[a]	[a]	[a]	14.3
323 - Printing and Related Support	[a]	[a]	[a]	[a]	13.3
315 - Apparel	[a]	[a]	[a]	[a]	N/A
316 - Leather and Allied Products	[a]	[a]	[a]	[a]	N/A
313 - Textile Mills	[a]	[a]	[a]	[a]	N/A
314 - Textile Product Mills	[a]	[a]	[a]	[a]	N/A
337 - Furniture and Related Products	[a]	[a]	[a]	[a]	N/A
Total	**143,230**	**109,302**	**16,216**	**17,712**	**N/A**

a Denotes instances where there was not enough information to impute a value

Calculated using 2018 MECS Table 3.2, Table 6.1, Table 11.1, Table 11.3 and Data Axle

3.3.4 Energy Storage

Information to characterize energy storage at New York State manufacturing facilities were limited despite research to identify resources and the examination of three sources. The study team investigated information to characterize electrochemical, battery, mechanical, compressed air, and thermal storage at manufacturing facilities in NY, all technologies financed by NY Green Bank. One source did identify a

small number of manufacturing battery energy storage projects, but it is uncertain whether this is fully representative of installed equipment.

- **DOE Global Energy Storage Database.** This database contains a validated and regularly updated record of electrical energy storage projects. It is often used as a key source of information to measure the growth of energy storage installations over time. However, the terms of use for this source explicitly prevented its use in any "repackaged versions in any form (e.g., reports) nor the ability to publicly display any work (e.g., text, tables), that directly uses the data from the database." In the study team's exploration of the database, it did not have meaningful information for this project. There are 40 storage projects listed in New York State, of which three are industrial and located at the same facility.
- **NYS Green Bank and New York Sun**. The New York Green Bank specializes in financing investments in the state's clean energy market. The New York Sun provides incentives and financing to make solar generation accessible for New York businesses (and homes). These investments are captured in databases available to the public. The team reviewed the available data and found 431 commercial and industrial solar and storage installations. Fourteen solar projects matched up with the screened industrial dataset. None of the 14 was an energy storage project.
- **NYSERDA DER Database.** This database contains open-source data on solar, energy storage, CHP, anaerobic digester, and fuel cell projects in New York State, with the ability to filter to specific industry sectors. An initial review of the database revealed 45 relevant manufacturing facilities, three of which were excluded after screening indicated the facilities were not involved in actual manufacturing production. Among the remaining facilities, seven had installed energy storage equipment, with the capacity by subsector shown in Table 3-20. This table also shows installed solar capacity as supplemental information to the renewable generation shown in Table 3-19.

Table 3-20. NYS direct manufacturing facility installed solar, storage, and fuel cell capacity

NAICS and Subsector Manufacturing Type	Solar Capacity (kW)	Storage Capacity (kW)	Fuel Cell Capacity (kW)	Blended Metric Rank
333 - Machinery	6,822	0	0	11.2
335 - Electrical Equip., Appliances, and Components	3,751	0	0	14.3
332 - Fabricated Metal Products	3,675	1,100	0	6.8
322 - Paper	3,505	0	0	2.9
336 - Transportation Equipment	3,458	1,000	0	9.1
339 – Miscellaneous	3,376	1,159	5,000	6.0
324 - Petroleum and Coal Products	2,700	0	0	6.5
311 - Food	1,342	0	0	5.4
327 - Nonmetallic Mineral Products	1,115	0	0	7.2
325 - Chemicals	1,025	0	0	3.5
321 - Wood Products	986	59	0	14.4
334 - Computer and Electronic Products	818	0	0	6.7
337 - Furniture and Related Products	783	0	0	N/A
326 - Plastics and Rubber Products	556	0	0	14.2
323 - Printing and Related Support	0	1,000	0	13.3
Total	**33,912**	**4,318**	**5,000**	**N/A**

Summarized from the NYSERDA DER database: https://der.nyserda.ny.gov/

3.4 Energy Use and Performance

3.4.1 Greenhouse Gas Emissions

Table 3-21 presents metric tons of GHG in carbon dioxide equivalent emissions overall and by product dollar by manufacturing subsector using data from 2018 MECS and the 2017 Economic Census. Table 3-22 also calculates metric tons of carbon dioxide emissions overall and by tier, with a per employee calculation by manufacturing subsector but using data from 2018 MECS and the screened manufacturing population (from Data Axle). The overall carbon dioxide emissions from Table 3-21 are 22.6 million metric tons of CO_{2e}, which is 24% higher than that calculated in Table 3-22 (14.9). While the two methods of calculation offer different estimates, the highest GHG-emitting manufacturing subsector, paper (322), is the same using both methods. Additionally, chemicals (325), primary metals (331), and nonmetallic mineral products (327) are among the top five highest GHG emitters in both tables. Reviewing the two sets of results together provides some confidence in understanding the importance of these subsectors relative to one another's consumption.

Table 3-21 shows that the overall emissions per product dollar ($kgCO_{2e}$/$) is 0.17, with a range from 0.03 for Machinery (333) to 0.70 for Primary Metals (322). Primary metals (331) also has a high emissions per product dollar at 0.61.

The breakdown of carbon emissions in Table 3-22 shows that 67% of it is from Tier 1 facilities. This is driven largely by Paper (322) and Primary Metals (331), which combined represent 55% of overall Tier 1 carbon emissions. Across all tiers, these two subsectors represent 46% of manufacturing emissions. Table 3-22 also shows that the overall emissions per employee is 58,974 $KgCO_2e$, with a range from 5,929 for Machinery (333) to 1,549,364 for Petroleum and Coal Products (324).

Note that only fossil fuel emissions could be calculated for transportation equipment (336), so that subsector's actual emissions rank and emissions per product dollar are higher than indicated below by an unknown amount.

Table 3-21. NYS imputed greenhouse gas emissions overall and per product dollar by manufacturing subsector

NAICS and Subsector Manufacturing Type	Total Emissions per Product Dollar ($KgCO_2e/\$$)	Total Metric Tons CO_2e ($MTCO_2e$)	Electric Metric Tons CO_2e ($MTCO_2e$)	Fossil Fuel Metric Tons CO_2e ($MTCO_2e$)	Subsector Rank	Blended Metric Rank
322 - Paper	0.70	4,861,630	270,954	4,590,676	1	2.9
325 - Chemicals	0.14	4,256,260	852,071	3,404,188	2	3.5
331 - Primary Metals	0.61	4,150,522	548,407	3,602,115	3	5.6
327 - Nonmetallic Mineral Products	0.51	2,140,496	263,779	1,876,717	4	7.2
311 - Food	0.08	1,723,895	515,211	1,208,683	5	5.4
321 - Wood Products	0.58	991,594	66,444	925,150	6	14.4
332 - Fabricated Metal Products	0.08	884,328	356,754	527,574	7	6.8
326 - Plastics and Rubber Products	0.07	582,197	308,106	274,091	8	14.2
324 - Petroleum and Coal Products	0.51	561,860	22,072	539,789	9	6.5
334 - Computer and Electronic Products	0.03	425,029	251,479	173,549	10	6.7
336 - Transportation Equipment	0.05	392,094	[a]	392,094	11	9.1
333 - Machinery	0.03	364,232	185,580	178,652	12	11.2
339 - Miscellaneous Manufacturing	0.05	339,794	127,566	212,228	13	6
312 - Beverage and Tobacco Products	0.08	265,239	105,689	159,551	14	10.6
335 - Electrical Eqt, Appliance, and Component	0.05	214,465	76,280	138,185	15	14.3
313 - Textile Mills	0.18	146,157	34,769	111,388	16	N/A
323 - Printing and Related Support Activities	0.04	139,783	78,690	61,093	17	13.3
337 - Furniture & Related Products	0.04	75,506	32,915	42,591	18	N/A
315 - Apparel	0.07	48,003	20,926	27,077	19	N/A
314 - Textile Product Mills	0.08	43,324	18,886	24,438	20	N/A
316 - Leather and Allied Products	0.00	[a]	[a]	[a]	N/A	N/A
Overall	**0.17**	**22,606,410**	**4,136,579**	**18,469,830**	**N/A**	N/A

a Denotes instances where there was not enough information to impute a value
Sources: Calculated from 2018 MECS Table 3.2, the 2017 Economic Census, and NYSERDA's Projected Emissions Factors for New York Grid Electricity, and Fossil and Biogenic Fuel Greenhouse Gas Emission Factors whitepapers

Table 3-22. NYS screened imputed greenhouse gas emissions – based on industrial value of shipments imputed from Data Axle industrial facilities

NAICS and Subsector Manufacturing Type	Total Metric Tons CO_2e ($MTCO_2e$)	Electric Metric Tons CO_2e ($MTCO_2e$)	Fossil Metric Tons CO_2e ($MTCO_2e$)	$KgCO_2e$ per Employee	Subsector Percent	Subsector Rank	Total Metric Tons CO_2e ($MTCO_2e$) by Tier			Blended Metric Rank
							1	2	3	
322 - Paper	5,667,927	360,081	5,307,846	476,336	31%	1	4,525,575	655,770	486,582	2.9
331 - Primary Metals	2,696,217	197,588	2,498,628	293,706	15%	2	2,170,707	264,395	261,114	5.6
324 - Petroleum and Coal Products	2,187,702	99,054	2,088,649	1,549,364	12%	3	1,917,038	63,828	206,837	6.5
327 - Nonmetallic Mineral Products	1,915,300	303,744	1,611,556	135,712	10%	4	1,404,775	109,984	400,540	7.2
325 - Chemicals	1,847,123	524,683	1,322,440	102,198	10%	5	1,216,934	250,075	380,114	3.5
311 - Food	802,502	266,092	536,410	33,736	4%	6	233,561	113,180	455,760	5.4
339 - Miscellaneous	641,328	188,440	452,887	13,697	4%	7	114,740	71,589	454,998	6
332 - Fabricated Metal Products	557,651	195,730	361,922	13,416	3%	8	36,305	49,882	471,464	6.8
321 - Wood Products	458,698	37,557	421,141	110,984	3%	9	85,011	43,670	330,018	14.4
336 - Transportation Equipment	a	a	403,546	a	N/A	10	a	a	a	9.1
334 - Computer and Electronic Products	372,443	253,242	119,201	10,611	2%	11	206,625	48,021	117,798	6.7
312 - Beverage and Tobacco Products	372,355	173,568	198,786	36,172	2%	12	157,194	41,578	173,583	10.6
326 - Plastics and Rubber Products	217,741	145,668	72,074	20,825	1%	13	68,596	58,992	90,153	14.2
335 - Electrical Equip., Appliances, and Components	210,126	91,934	118,192	16,704	1%	14	83,761	25,302	101,063	14.3
323 - Printing and Related Support	184,033	114,483	69,550	16,664	1%	15	21,144	18,338	144,551	13.3
333 - Machinery	153,653	72,182	81,471	5,929	1%	16	23,575	21,650	108,428	11.2
313 - Textile Mills	a	a	a	a	N/A	N/A	a	a	a	N/A
314 - Textile Product Mills	a	a	a	a	N/A	N/A	a	a	a	N/A
315 - Apparel	a	a	a	a	N/A	N/A	a	a	a	N/A
316 - Leather and Allied Products	a	a	a	a	N/A	N/A	a	a	a	N/A
337 - Furniture and Related Products	a	a	a	a	N/A	N/A	a	a	a	N/A
Overall	**18,284,799**	**3,024,045**	**15,260,754**	**58,974**	**100%**	**N/A**	**12,265,541**	**1,836,253**	**4,183,005**	**N/A**

a Denotes instances where there was not enough information to impute a value.

Source: Calculated using 2018 MECS Table 3.2, Table 6.1, NYSERDA's Projected Emissions Factors for New York Grid Electricity whitepaper, NYSERDA's Fossil and Biogenic Fuel Greenhouse Gas Emission Factors whitepaper, and subsector facility-level employment values from Data Axle

3.4.2 Energy Management Practices

Energy management activities and the source of assistance are tracked in the MECS national survey sample. Table 3-23 shows the percentage of all manufacturing establishments (NAICS 311-339) that reported undertaking various energy management activities (in-house, utility/energy supplier, product/service provider, and government sponsored programs) at the national level. These results were calculated using the number of participating establishments as a percent of total establishments. The second column shows the overall percent of manufacturers that reported undertaking a given energy management activity followed by the source of assistance received for that activity. The overall percent in each row is slightly smaller than the sum of the sources as respondents could offer multiple sources per activity. The largest portion of energy-management activities are done either in-house, with the utility/energy supplier, or with the product/service provider. Federal, state, and local programs comprise a very small portion of assistance among all energy management activities.

Table 3-23. National percent of establishments participating in general energy-management activities (all manufacturing categories)

Energy Management Activities	Source of Assistance						
	Overall	In-house	Utility/ Energy Supplier	Product/ Service Provider	Federal Program	State/Local Program	Don't Know
Energy Audit	18%	8%	8%	4%	<1%	1%	<1%
Technical Assistance	12%	5%	4%	5%	<1%	<1%	<1%
Financial Assistance	9%	1%	5%	1%	<1%	2%	<1%
Technical Information	8%	4%	2%	3%	<1%	<1%	<1%
Training	7%	4%	2%	2%	<1%	<1%	<1%

Source: Calculated from 2018 MECS Table 8.1

In addition to the national-level data, Table 3-24 provides summary-level information on the measures that were installed through NYSERDA's IPE program from 2017 to 2022. Among electric measures, general process improvements accounted for the greatest amount of savings, while Other, Variable Frequency Drives (VFDs), and Heat Recovery were the next highest saving measures overall. On a per-measure basis, air compressor motors had the highest level of savings. Among gas measures, HVAC boilers accounted for the greatest amount of savings, both overall and on a per-measure basis.

Table 3-24. NYS measures installed through the IPE program, 2017-2022

Measure Type	Applicants	Facilities	Measures	Electric Savings - MWh	Gas or Alternate Fuel Savings - MMBtu
Process Improvement	25	25	68	21,702	72,710
Other	14	19	30	6,759	231,971
VFDs	4	8	11	4,780	0
Heat Recovery	6	6	16	3,095	21,326
Air Compressor - Motors	2	3	3	2,903	0
HVAC - Chiller	3	3	6	1,458	0
HVAC - Boiler	6	6	22	1,337	366,993
Pumps	1	1	3	1,304	0
Wastewater System	1	1	5	1,144	68,318
Motors	2	2	4	830	0
New Process	1	1	2	487	0
Air Compressor - Tank	0	1	4	368	0
HVAC - Controls	1	1	5	234	3,845
Air Compressor - VFDs	1	1	1	222	0
HVAC - Motors	3	3	5	72	578
Lighting	1	1	1	5	0
Fuel Conversion	1	1	3	0	0
Total	**72**	**83**	**189**	**46,701**	**765,743**

Source: NYSERDA IPE program database

Table 3-25 presents the percent of establishments in each NAICS code that participated in various energy management activities. Energy audits and technical assistance are regularly undertaken among most NAICS codes, in particular Beverage and Tobacco (336), Chemical (325), Electrical Equipment (335), Paper (322), Petroleum (324), Plastics (326), and Primary Metals (331). Generally, subsector activity in most energy management areas remains about the same relative to other subsectors. In other words, subsectors tend to either be among the highest in all areas or the lowest in all areas.

Table 3-25. National percent of establishments participating in general energy management activities by NAICS code

NAICS and Subsector Name	Energy Management Activities					Blended Metric Rank
	Energy Audit	Technical Assistance	Technical Information	Training	Financial Assistance	
322 - Paper	28%	18%	9%	13%	10%	2.9
325 - Chemicals	29%	23%	14%	15%	7%	3.5
311 - Food	20%	17%	13%	11%	12%	5.4
331 - Primary Metals	29%	26%	17%	14%	17%	5.6
339 - Miscellaneous Mfg	14%	7%	3%	3%	5%	6.0
324 - Petroleum & Coal Products	33%	30%	21%	25%	9%	6.5
334 - Computer & Electronic Products	20%	12%	10%	10%	9%	6.7
332 - Fabricated Metal Products	14%	7%	5%	2%	7%	6.8
327 - Nonmetallic Mineral Products	19%	15%	10%	10%	8%	7.2
336 - Transportation Equipment	19%	19%	15%	9%	15%	9.1
312 - Beverage & Tobacco Products	27%	19%	14%	12%	13%	10.6
333 - Machinery	17%	12%	6%	5%	7%	11.2
323 - Printing & Related Support Activities	12%	5%	3%	3%	7%	13.3
326 - Plastics & Rubber Products	31%	20%	14%	14%	16%	14.2
335 - Electrical Equip, Appliance, & Component	25%	14%	10%	13%	17%	14.3
321 - Wood Product	13%	9%	6%	5%	9%	14.4
337 - Furniture & Related Products	13%	7%	4%	4%	9%	N/A
316 - Leather & Allied Products	6%	6%	2%	2%	4%	N/A
313 - Textile Mills	14%	15%	11%	9%	10%	N/A
314 - Textile Product Mills	13%	[a]	[a]	[a]	[a]	N/A
315 - Apparel	30%	[a]	[a]	[a]	17%	N/A

a Denotes instances where there was not enough information to impute a value
Source: Calculated from MECS Table 8.1

Table 3-26 presents MECS findings on specific activities a manufacturing facility might undertake or have the availability to use to improve or manage facility or system energy. Energy efficiency being incorporated into equipment purchasing decisions was by far the most frequently cited activity, at 72% among those asked. This was distantly followed by a cluster of activities undertaken by about a quarter of respondents, including awareness of ISO 50001, tracking energy use as a baseline for future use comparison, explicit goals for improving energy consumption, keeping an inventory of motors, and detecting and controlling compressed air leaks.

Table 3-26. National percentage of establishments participating in specific energy-management activities (all manufacturing categories)

Energy Management Activities	Reported Rate
Energy Efficiency a part of Purchasing Decision	72%
Keep an Inventory of All Motors	28%
Detect and Control Compressed Air Leaks	28%
Aware of ISO 50001	25%
Energy Use Baseline for Comparing Energy Use in Future Years	24%
Set Goals for Improving Energy Consumption	23%
Person(s) Responsible for Energy Management	16%
Procedures to Reduce Electricity Consumption in Times of Critical Grid Conditions	14%
Implementing ISO 50001	13%
Conduct Audits to Identify Energy Saving Opportunities	13%
Quantitative Goals	12%
Measure Oxygen and Carbon Dioxide Levels	10%
Submetering (metering beyond the main utility, revenue, or supplier meter)	9%
Automation Controls to Reduce Electricity Consumption in Times of Critical Grid Conditions	6%
Use Flue Gas to Preheat Other Equipment or Processes	5%
Track the Amount of Energy Spent in Compressed Air Systems	5%

Source: Percentages calculated directly from 2018 MECS Table 8.4

Table 3-27 and Table 3-28 show the energy management activities by NAICS code that were present more than 10% of the time. The team eliminated from the analysis those with frequency below 10% to explore where higher-incidence activities are occurring by NAICS code. The most frequently reported energy management activity, considering energy efficiency in purchasing decisions, is consistently reported to occur at over 64% of facilities regardless of manufacturing subsector. Primary Metals (331), Petroleum and Coal Products (334), and Paper (322) average higher rates of engagement across all activities while Textile Products (314), Textile Mills (313), and Leather (316) show less activity engagement overall.

Table 3-27. National percentage of establishments participating in specific energy-management activities by NAICS code (Part 1)

NAICS and Subsector Name	Energy Mgmt. Staff	Aware of ISO 50001	Imple-ment ISO 50001	Energy Efficiency Purchases	Energy Baseline Compari-sons	Goals for Reducing Energy Consumption	Quant-itative Goals	Energy Saving Audits	Blended Metric Rank
322 - Paper	29%	44%	6%	82%	47%	36%	21%	24%	2.9
325 - Chemicals	29%	39%	13%	71%	47%	35%	25%	21%	3.5
311 - Food	21%	20%	17%	74%	28%	30%	15%	14%	5.4
331 - Primary Metals	29%	39%	13%	76%	40%	34%	21%	20%	5.6
339 - Miscellaneous Mfg	16%	27%	13%	76%	17%	22%	9%	6%	6.0
324 - Petroleum & Coal Products	34%	39%	11%	71%	45%	41%	19%	20%	6.5
334 - Computer & Electronic Products	27%	33%	[a]	[a]	34%	27%	22%	17%	6.7
332 - Fabricated Metal Products	11%	21%	12%	70%	17%	19%	8%	9%	6.8
327 - Nonmetallic Mineral Products	14%	26%	9%	67%	24%	22%	8%	12%	7.2
336 - Transportation Equipment	20%	37%	16%	67%	31%	27%	20%	20%	9.1
312 - Beverage & Tobacco Products	26%	26%	16%	81%	36%	36%	19%	14%	10.6
333 - Machinery	15%	25%	17%	75%	22%	20%	10%	14%	11.2
323 - Printing & Related Support Activities	11%	15%	[a]	75%	16%	15%	9%	9%	13.3
326 - Plastics & Rubber Products	24%	38%	20%	a	34%	33%	18%	21%	14.2
335 - Electrical Equipment, Appliance, & Component	19%	30%	12%	[a]	21%	26%	[a]	18%	14.3
321 - Wood Product	29%	39%	13%	76%	40%	34%	21%	20%	14.4
337 - Furniture & Related Products	8%	10%	[a]	65%	10%	9%	[a]	6%	N/A
316 - Leather & Allied Products	18%	15%	4%	[a]	8%	7%	3%	11%	N/A
313 - Textile Mills	24%	25%	4%	[a]	27%	29%	18%	13%	N/A
314 - Textile Product Mills	11%	18%	[a]	[a]	15%	25%	[a]	[a]	N/A
315 - Apparel	[a]	1%	0%	[a]	[a]	20%	[a]	20%	N/A

a Denotes instances where there was not enough information to impute a value
Source: Percentages calculated directly from MECS Table 8.4

Table 3-28. National percentage of establishments participating in specific energy-management activities by NAICS code (Part 2)

NAICS and Subsector Name	Demand Response Prog.	O_2/CO_2 Measur-ments	Imple-ment ISO 50001	Furnace Inspec-tions	Heat Transfer Equip-ment	Process Heating Equip-ment	Motor Inven-tory	Control Comp. Air leaks	Comp. Air Energy Tracking	Blended Metric Rank
322 - Paper	23%	26%	6%	51%	50%	52%	46%	34%	13%	2.9
325 - Chemicals	18%	27%	13%	53%	53%	60%	46%	38%	10%	3.5
311 - Food	12%	22%	17%	51%	51%	54%	38%	25%	7%	5.4
331 - Primary Metals	31%	24%	13%	59%	53%	62%	45%	34%	10%	5.6
339 - Miscellaneous Mfg	10%	4%	13%	33%	30%	33%	22%	25%	2%	6.0
324 - Petroleum & Coal Products	22%	45%	11%	56%	58%	62%	49%	27%	5%	6.5
334 - Computer & Electronic Products	14%	8%	[a]	42%	36%	43%	26%	31%	8%	6.7
332 - Fabricated Metal Products	11%	5%	12%	34%	30%	29%	22%	28%	3%	6.8
327 - Nonmetallic Mineral Products	14%	11%	9%	32%	30%	32%	30%	27%	4%	7.2
336 - Transportation Equipment	18%	11%	16%	32%	34%	32%	24%	31%	8%	9.1
312 - Beverage & Tobacco Products	25%	13%	16%	36%	40%	47%	35%	26%	6%	10.6
333 - Machinery	13%	8%	17%	41%	40%	36%	29%	27%	4%	11.2
323 - Printing & Related Support Activities	13%	3%	[a]	32%	30%	28%	21%	21%	1%	13.3
326 - Plastics & Rubber Products	24%	10%	20%	36%	38%	44%	41%	45%	8%	14.2
335 - Electrical Equip, Appliance, & Component	24%	17%	12%	42%	46%	50%	31%	29%	9%	14.3
321 - Wood Products	31%	24%	13%	59%	53%	62%	45%	34%	10%	14.4
337 - Furniture & Related Products	10%	4%	[a]	28%	27%	23%	19%	22%	[a]	N/A
316 - Leather & Allied Products	12%	2%	4%	22%	22%	28%	18%	24%	1%	N/A
313 - Textile Mills	28%	14%	4%	43%	43%	43%	35%	37%	11%	N/A
314 - Textile Product Mills	[a]	2%	[a]	16%	18%	19%	13%	[a]	[a]	N/A
315 - Apparel	3%	2%	0%	17%	16%	[a]	15%	5%	[a]	N/A

a Denotes instances where there was not enough information to impute a value
Source: Percentages calculated directly from 2018 MECS Table 8.4

Table 3-29 presents the reported rate of three specific activities a manufacturer might undertake to ensure higher oven and heating efficiencies at a manufacturing facility. The rate of performing these three activities is consistently around 37%, suggesting that the manufacturers that implement one of them likely implement all three of them.

Table 3-29. National percentage of establishments participating in process heating maintenance program activities (all manufacturing categories)

Process Heating Maintenance Program Activities for…	Reported Rate
Furnace Inspections	37%
Inspecting, Calibrating, and Adjusting Process Heating Equipment	37%
Cleaning of Heat Transfer Equipment	36%

Source: Percentages calculated directly from 2018 MECS Table 8.4

3.4.3 Low-Carbon Fuels

Table 3-30 shows the ability of manufacturing establishments to switch from a carbon-intensive fuel to a low-carbon alternative per MECS. Specifically, this means the capability to substitute fuels within 30 days without extensive modifications. A low-carbon alternative in this analysis is natural gas, which is comparatively lower, but not necessarily the lowest available. The percentages in Table 3-30 represent the national percent of all establishments in a NAICS category that can switch any portion of their consumed fuel from a carbon-intensive fuel to natural gas. In NAICS sector Plastics and Rubber Products (326), 100% of processes that use residual fuel oil can switch all or a portion of their process to natural gas, but no ability to switch other fuels. Subsectors Chemicals (325), Food (311), and Nonmetallic Mineral Products (327) have the highest ability to switch to a low-carbon fuel in most of their fuel consumption streams.

Table 3-30. National percentage of establishments able to switch to lower-carbon fuels

NAICS and Subsector Name	Ablity to Switch from Residual Fuel Oil to Natural Gas	Rank	Ablity to Switch from Distillate Fuel Oil to Natural Gas	Rank	Ablity to Switch from Coal to Natural Gas	Rank	Ablity to Switch from HGL to Natural Gas	Rank	Blended Metric Rank
315 - Apparel	[a]	N/A	[a]	N/A	[a]	N/A	[a]	N/A	N/A
312 - Beverage & Tobacco Products	60%	2	[a]	N/A	0%	5	4%	3	10.6
325 - Chemicals	33%	4	17%	1	12%	4	2%	4	3.5
334 - Computer & Electronic Products	0	6	2%	5	[a]	N/A	<1%	5	6.7
335 - Electrical Equip, Appliance, & Component	[a]	N/A	[a]	N/A	[a]	N/A	0%	6	14.3
332 - Fabricated Metal Products	[a]	N/A	[a]	N/A	[a]	N/A	[a]	N/A	6.8
311 - Food	[a]	N/A	6%	3	30%	2	5%	2	5.4
337 - Furniture & Related Products	[a]	N/A	0%	8	[a]	N/A	<1%	5	N/A
316 - Leather & Allied Products	[a]	N/A	[a]	N/A	[a]	4	[a]	N/A	N/A
333 - Machinery	[a]	N/A	[a]	N/A	[a]	N/A	<1%	5	11.2
339 - Miscellaneous Mfg	[a]	N/A	0%	8	[a]	N/A	<1%	5	6.0
327 - Nonmetallic Mineral Products	[a]	N/A	<1%	7	23%	3	8%	1	7.2
322 - Paper	21%	5	7%	2	35%	1	8%	1	2.9
324 - Petroleum & Coal Products	43%	3	3%	4	[a]	N/A	4%	3	6.5
326 - Plastics & Rubber Products	100%	1	[a]	N/A	[a]	4	[a]	N/A	14.2
331 - Primary Metal	[a]	N/A	[a]	N/A	[a]	4	2%	4	5.6
323 - Printing & Related Support Activities	[a]	N/A	0%	8	[a]	4	[a]	N/A	13.3
313 - Textile Mills	[a]	N/A	[a]	N/A	[a]	4	[a]	N/A	N/A
314 - Textile Product Mills	[a]	N/A	[a]	N/A	[a]	N/A	[a]	N/A	N/A
336 - Transportation Equipment	0%	6	1%	6	[a]	4	<1%	5	9.1
321 - Wood Products	0%	6	<1%	7	[a]	N/A	2%	4	14.4

3.4.4 Beneficial Electrification

Table 3-31 presents the national percentages of establishments that can switch from a fossil fuel to electricity. In most manufacturing subsectors, the largest percentage of facilities able to switch to electricity is for switching from HGLs (e.g., propane, butane, ethene). The Paper manufacturing subsector (322) has the largest percentage of establishments able to switch to electricity for both natural gas and HGLs. The ability to switch from natural gas to electricity is greatest in Paper (322), Apparel (315), Fabricated Metals (332), and Chemical (325). The ability to switch from distillate fuel oil to electricity is greatest in Food (311), and there is little opportunity to switch from residual fuel oil or coal. The tables in this section are at the national level.

Table 3-31. National percentage of establishments that can switch from a fossil fuel to electricity

NAICS and Subsector Name	Percent of establisments able to switch from…					Blended Metric Rank
	Nat. Gas to Electricity	Residual Fuel Oil to Electricity	Distillate Fuel Oil to Electricity	Coal to Electricity	HGL[31] to Electricity	
315 - Apparel	5%	[a]	[a]	[a]	[a]	N/A
312 - Beverage & Tobacco Products	>1%	0%	a	0%	7%	10.6
325 - Chemicals	4%	0%	a	0%	12%	3.5
334 - Computer & Electronic Products	[a]	0%	3%	0%	[a]	6.7
335 - Electrical Equip, Appliance, & Component	[a]	[a]	[a]	0%	[a]	14.3
332 - Fabricated Metal Products	5%	a	a	0%	5%	6.8
311 - Food	2%	0%	5%	0%	11%	5.4
337 - Furniture & Related Products	[a]	[a]	0%	[a]	[a]	N/A
316 - Leather & Allied Products	1%	[a]	[a]	0%	0%	N/A
333 - Machinery	3%	[a]	0%	[a]	6%	11.2
339 - Miscellaneous Mfg	[a]	[a]	0%	[a]	[a]	6.0
327 - Nonmetallic Mineral Products	3%	[a]	[a]	0%	8%	7.2
322 - Paper	6%	0%	[a]	[a]	13%	2.9
324 - Petroleum & Coal Products	4%	0%	3%	[a]	6%	6.5
326 - Plastics & Rubber Products	[a]	0%	[a]	0%	9%	14.2
331 - Primary Metals	2%	[a]	3%	0%	3%	5.6
323 - Printing & Related Support Activities	[a]	[a]	0%	0%	[a]	13.3
313 - Textile Mills	2%	[a]	0%	0%	[a]	N/A
314 - Textile Product Mills	[a]	[a]	[a]	[a]	0%	N/A
336 - Transportation Equipment	4%	0%	[a]	0%	2%	9.1
321 - Wood Products	5%	0%	>1%	[a]	3%	14.4

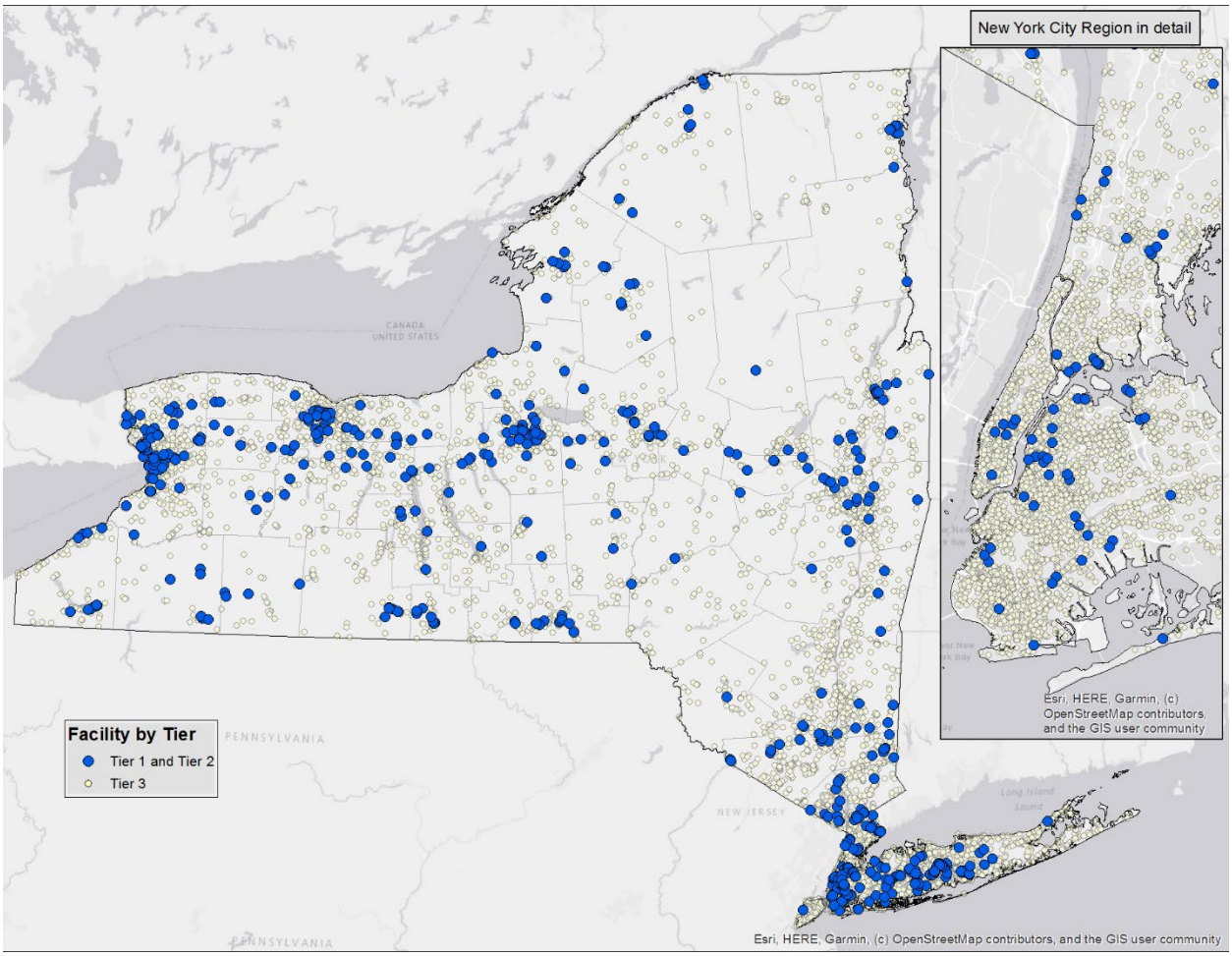
a Denotes instances where there was not enough information to impute a value
Source: Calculated from 2018 MECS Tables 10.3, 10.5, 10.9, 10.11, 10.13

[31] Hydrocarbon gas liquid (e.g., propane or butane)

3.5 Disadvantaged Communities Geospatial Results

There are three subsections that contain the results fo the disadvantaged communities (DACs) geospatial results. These sections include manufacturing proximity to DACs, manufacturing emissions within DAC block groups, and industrial activity within DACs.[32] The map in Figure 3-1 illustrates the location of all statewide facilities by tier and screening status. Tier 1 and Tier 2 facilities have larger blue circles while Tier 3 facilities are smaller and faded. The study team includes all Tier 3 facilities in this map, including those that may not be manufacturing, due to the inability to perform full screening of the Tier 3 population.

Figure 3-1. Facility locations by tier



[32] The DACs used in this analysis were those identified by NYSERDA as qualified at https://www.nyserda.ny.gov/ny/disadvantaged-communities the time of reporting. The definition of DAC is expected to expand as NYSERDA continues to refine its criteria.

3.5.1 Manufacturing proximity to disadvantaged communities

As described in Section 2.6, the geographic analysis determined the distance between each screened facility and each DAC via connecting roads. Table 3-32 presents the numbers of facilities and total employment by distance to the nearest DAC, for manufacturing facilities in Tiers 1 and Tier 2. For these two tiers, actual manufacturing activity was confirmed in the screening process described in Section 2.3. Just under 60% of this population's total number of firms and total employment is within 2.5 miles of the nearest DAC, while the remaining 40% was within 35 miles of the nearest DAC.[33]

Table 3-32. Tier 1 and 2 manufacturing facility relationship to nearest DAC

Facility Relationship to Nearest DAC	Number of Facilities	Total Weighted Employment
Within DAC Border	139	42,807
Within 2.5 Miles of DAC	181	46,192
Between 2.5 Miles and 10 Miles of DAC	163	50,165
Between 10 Miles and 35 Miles of DAC	54	9,603
Outside 35 Miles of DAC or Unmatched Address	10	2,909
Total	547	151,677

Table 3-33 presents the corresponding information for Tier 3 facilities. For this tier, only a small fraction of facilities were screened, so that actual manufacturing status was not confirmed individually for the large majority. Based on screening described in Section 2.3, an estimated 40% of the Tier 3 facilities in this analysis are not manufacturing products. Employment at each individual Tier 3 facility is weighted to reflect that some of the unscreened facilities are not actually manufacturing facilities despite their NAICS code. However, for the geographic analysis, the study team included all locations that were in Tier 3, had a manufacturing NAICS code, and were not explicitly identified as ineligible. This was done because facilities cannot exist as a fraction for the network analysis – they are either a location to solve the network for, or the location does not exist. The implication of including all eligible and not screened facilities is that the total facility count in the geographic section is higher than elsewhere in the report. This decision also impacted a small number of Tier 1 and Tier 2 facilities. For the (predominantly unscreened) Tier 3 facilities, nearly two-thirds of the facilities and employment were within 2.5 miles of the nearest DAC, and nearly all the remainder is within 35 miles. This represents a slightly higher ratio of employment and facilities within 2.5 miles of a DAC than was observed with Tiers 1 and 2.

[33] The 2.5-mile and 35-mile break points were selected based on a literature review and approximate the maximum distance that the majority of commuters travel when walking, or driving, to work respectively.

Table 3-33. Tier 3 manufacturing facility relationship to nearest DAC

Facility Relationship to Nearest DAC	Number of Facilities	Total Weighted Employment
Within DAC Border	4,792	40,578
Within 2.5 Miles of DAC	7,888	57,777
Between 2.5 Miles and 10 Miles of DAC	4,542	48,773
Between 10 Miles and 35 Miles of DAC	1,174	10,769
Outside 35 Miles of DAC or Unmatched Address	26	474
Grand Total	18,422	158,372

a Includes approximately 40% non-manufacturing facilities within manufacturing NAICS subsectors

The number of facilities within 2.5 miles and 35 miles of each DAC block group centroid can also be examined through a network routing layer that uses a 1-mile proximity to a bus and subway network filter to identify DAC block groups that could access mass transit to arrive at a facility. These analyses generate a spatial relationship between each DAC block group and the facilities that the households in the DAC block group can access given the network parameters. This analysis also provides insight into which facilities are accessible from multiple DAC block groups and serves as the shared spatial relationship enabling the team to characterize what the different DACs look like relative to the facilities they are in spatial proximity with. Finally, this analysis provides the visual sense of which areas and DAC block groups have higher concentrations of industries and employment, and which areas have lower concentrations. The summary tables presented in this section can provide an understanding whether there are sectors where facilities and employment are substantively different relative to spatial proximity to DAC. Geographic data can be used to better understand sub-regional variations within and reveal sub-regional trends in employment coverage relative to local DACs. At the most granular level, the underlying data comprised individual blocks and facility relationship can be leveraged to understand specific community or facility contributions to the statewide picture.

Figure 3-2 indicates the location of each Tier 1 and 2 facility, coded by its proximity to the nearest DAC. This provides an indication of the relative density and locations of the manufacturing facilities in the analysis. Figure 3-3 presents the total employment for each facility and the total DAC population below the poverty index of 2.0 per grid cell. The total DAC population below the poverty index of 2.0 for each cell is calculated by adding the total number of residents of each DAC to any hexagonal cell that falls within the block group.

This analysis can be used to identify areas where there are higher levels of employment to DAC residents whose income is below 200% of the poverty index threshold. This would indicate the potential for greater manufacturing job opportunities for the local population. Examples include central Long Island and the suburbs of Buffalo and Rochester. Conversely, the urban cores of New York, Buffalo, and Syracuse tend to have greater numbers of DAC residents than manufacturing jobs, indicating potentially fewer

employment opportunities in the manufacturing sector. This type of spatial targeting can enable stakeholders to identify and prioritize which areas may make sense to better survey or otherwise assess in order to reduce the uncertainty in the relationship of jobs to DAC residents. It can also identify areas that can be prioritized for local stakeholder outreach or targeted policy interventions.

Figure 3-2. Tiers 1 and 2 facility locations by distance to nearest DAC

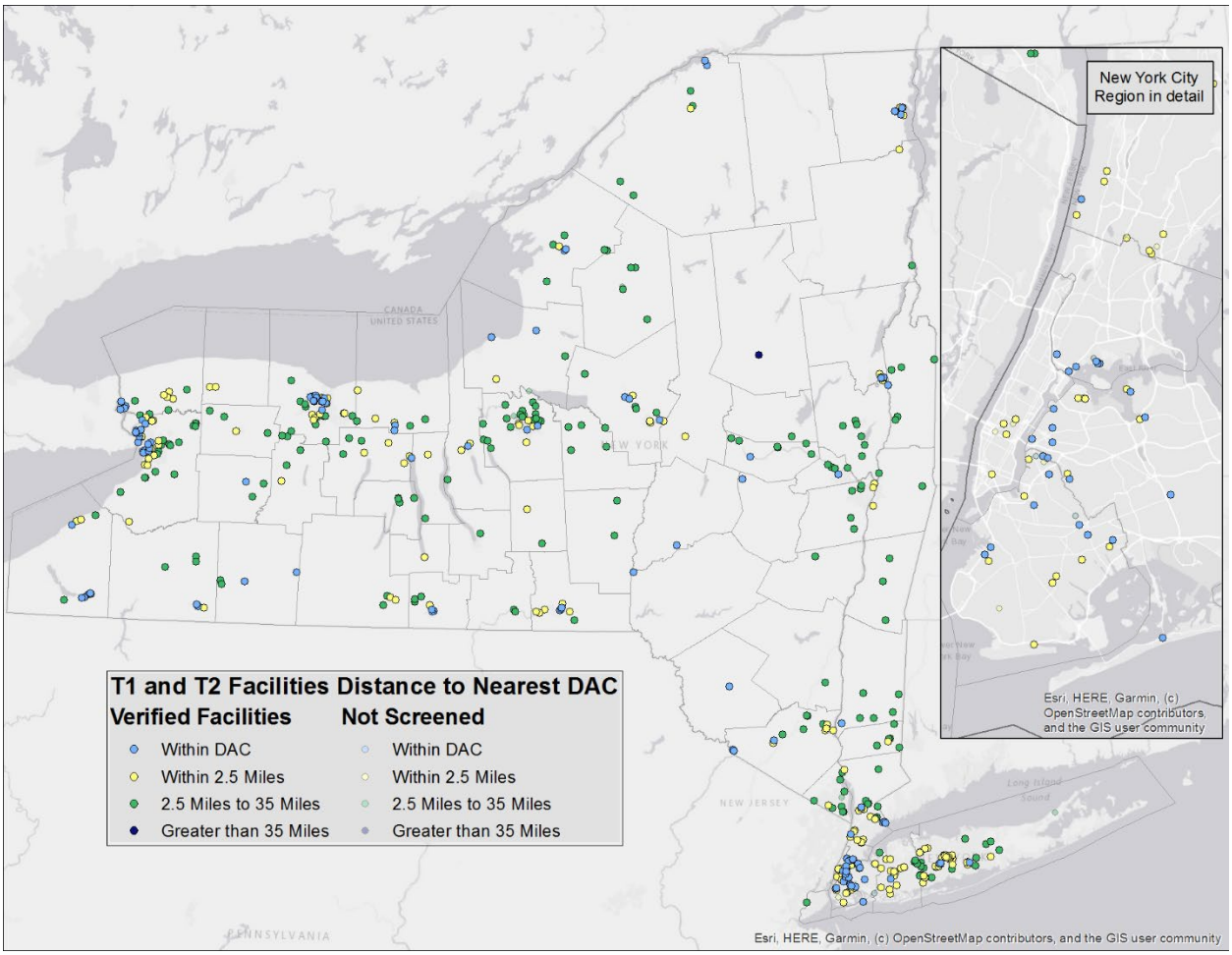
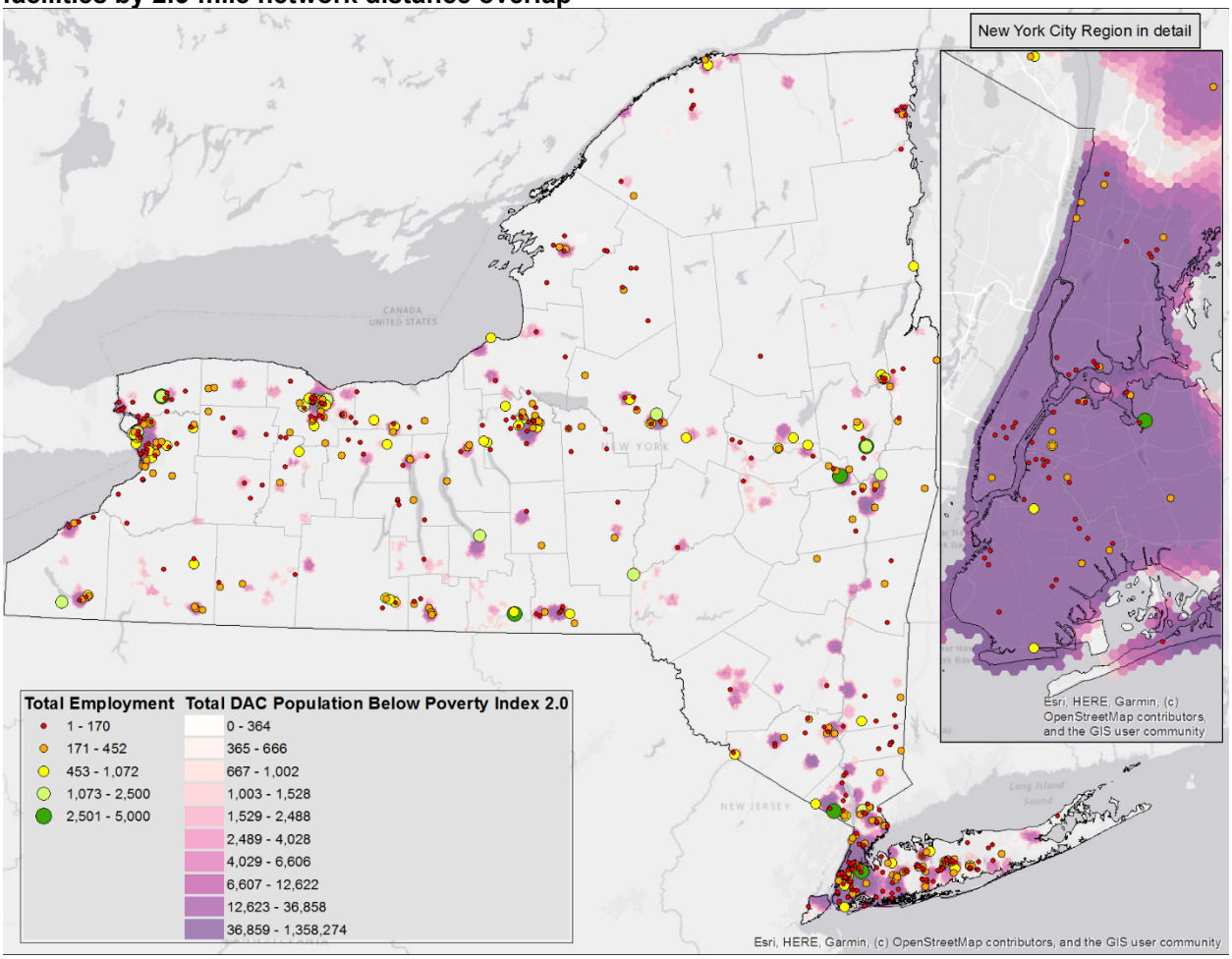


Figure 3-3. Total employment to DAC population below poverty index 2.0 for Tier 1 and Tier 2 facilities by 2.5-mile network distance overlap



The spatial relationship between any one DAC and any one facility is exclusive – i.e., the facility can only be one distance from the DAC analysis point. However, the relationship between a single facility and the population of DACs is not exclusive – e.g., a facility can be 1 mile from one DAC and 2.5 miles from a second DAC. This is an important qualifier in assessing the following tables, as to facilitate consumption of the data, the study team has assigned each facility's employment into the distance range for the nearest DAC block group to that facility. This results in a table that is additive across both the rows and columns when looking at employment and facility counts.

Table 3-34 presents the total number of facilities from Tiers 1 and 2 by distance to the nearest block group. Table 3-35 presents the total employment by distance to the nearest block group.

Table 3-34. Number of Tier 1 and 2 facilities to nearest DAC

NAICS and Subsector Name	Total Facilities	Distance to nearest DAC				
		Within DAC Border	Within 2.5 Miles of DAC	Between 2.5 Miles and 10 Miles of DAC	Between 10 Miles and 35 Miles of DAC	Outside 35 Miles of DAC or Unmatched Address
322 - Paper	103	32	28	28	13	2
325 - Chemicals	61	14	19	25	2	1
331 - Primary metals	55	20	12	13	9	1
324 - Petroleum & coal products	53	9	20	20	4	0
327 - Nonmetallic mineral products	46	10	12	16	6	2
311 - Food	40	9	16	7	5	3
334 - Computer & electronic products	34	7	13	14	0	0
326 - Plastics & rubber products	32	14	8	6	3	1
336 - Transportation equipment	27	7	11	6	3	0
312 - Beverage & tobacco products	25	5	8	11	1	0
332 - Fabricated metal products	20	4	9	3	4	0
339 - Miscellaneous mfg	17	1	8	7	1	0
333 - Machinery	11	5	4	1	1	0
335 - Electrical equipment, appliance, & component	10	1	5	3	1	0
323 - Printing & related support activities	8	1	6	1	0	0
321 - Wood products	4	0	1	2	1	0
315 - Apparel	1	0	1	0	0	0

Table 3-35. Total Tier 1 and 2 weighted employment to nearest DAC

NAICS and Subsector Name	Total Employment	Distance to nearest DAC				
		Within DAC Border	Within 2.5 Miles of DAC	Between 2.5 Miles and 10 Miles of DAC	Between 10 Miles and 35 Miles of DAC	Outside 35 Miles of DAC or Unmatched Address
334 - Computer & electronic products	24,249	3,779	4,834	15,636	0	0
336 - Transportation equipment	16,759	2,842	8,304	4,903	710	0
325 - Chemicals	14,373	5,084	2,480	5,901	360	548
339 - Miscellaneous mfg	13,555	500	5,721	6,934	400	0
311 - Food	11,489	2,260	4,981	1,476	1,647	1,124
327 - Nonmetallic mineral products	11,192	5,282	2,274	2,404	1,015	217
322 - Paper	10,881	3,731	2,679	2,434	1,612	424
331 - Primary metals	8,332	3,662	1,363	1,830	1,116	360
333 - Machinery	8,133	3,763	2,370	1,500	500	0
332 - Fabricated metal products	7,963	1,462	4,210	1,051	1,240	0
335 - Electrical equipment, appliance, & component	7,307	4,800	1,662	615	230	0
326 - Plastics & rubber products	6,557	4,012	904	1,070	335	236
312 - Beverage & tobacco products	5,711	1,326	1,605	2,690	90	0
323 - Printing & related support activities	2,150	150	1,300	700	0	0
324 - Petroleum & coal products	1,282	154	664	406	58	0
321 - Wood products	1,105	0	200	615	290	0
315 - Apparel	640	0	640	0	0	0

Table 3-36 presents the total number of DAC residents below a poverty index of 2.0 per the American Communities Survey (ACS). We provide these results as poverty index is one of the factors used by the New York State to define DACs. In this table, a block group population can appear in multiple rows as the individual block group will have a spatial relationship to facilities in different NAICS codes, therefore the columns are not additive. However, the population totals are additive within each row, and can be used to get a sense of scale of the number of residents of DACs in proximity to business and employment be the different NAICS sectors.

Table 3-36. Tier 1 and 2 total weighted employment to DAC block group's ACS population below 2.0 poverty index by distance

NAICS and Subsector Name	Total Emp.	Population within (ACS)				
		Within 0.5 miles	0.5 to 1 miles	1 to 1.5 miles	1.5 to 2 miles	2 to 2.5 miles
334 - Computer & electronic products	24,249	28,046	29,192	46,164	50,309	43,425
336 - Transportation equipment	16,759	29,205	49,206	29,084	32,366	37,973
325 - Chemicals	14,373	25,429	61,258	107,408	176,082	189,518
339 - Miscellaneous mfg	13,555	7,502	9,526	11,175	29,146	40,271
311 - Food	11,489	75,534	84,393	102,394	82,477	87,937
327 - Nonmetallic mineral products	11,192	17,598	38,251	46,151	60,909	74,841
322 - Paper	10,881	149,585	276,706	353,573	372,245	279,752
331 - Primary metals	8,332	88,099	146,553	199,820	282,857	353,291
333 - Machinery	8,133	41,092	58,885	80,248	78,770	97,050
332 - Fabricated metal product	7,963	24,793	23,953	37,367	33,126	42,436
335 - Electrical equip., appliance, & component	7,307	484	7,007	8,507	9,338	9,874
326 - Plastics & rubber products	6,557	51,175	65,373	98,199	161,660	185,165
312 - Beverage & tobacco products	5,711	7,887	9,861	27,564	36,318	40,901
323 - Printing & related support activities	2,150	6,863	15,160	28,166	61,228	89,642
324 - Petroleum & coal products	1,282	40,351	114,501	188,373	268,701	265,139
321 - Wood products	1,105	0	0	0	1,485	267
315 - Apparel	640	0	0	0	1,580	913

Figure 3-4 provides the location of Tier 3 facilities, colored by the facilities' proximity to the nearest DAC, including those within a DAC. As noted previously, all Tier 3 facilities are included in the DAC network analysis though the screening indicated that a sizable proportion of these facilities are unlikely to be industrial despite their NAICS code classification. To facilitate transparency into screened and verified locations versus the unscreened locations, the map presents the screened dots as a slightly larger and brighter series of points; facilities that were not screened are presented using the same color scheme but as smaller and faded points. Employment at any given facility has been weighted as appropriate based on the screening results.

Figure 3-4. Tier 3 distance to nearest DAC by network path

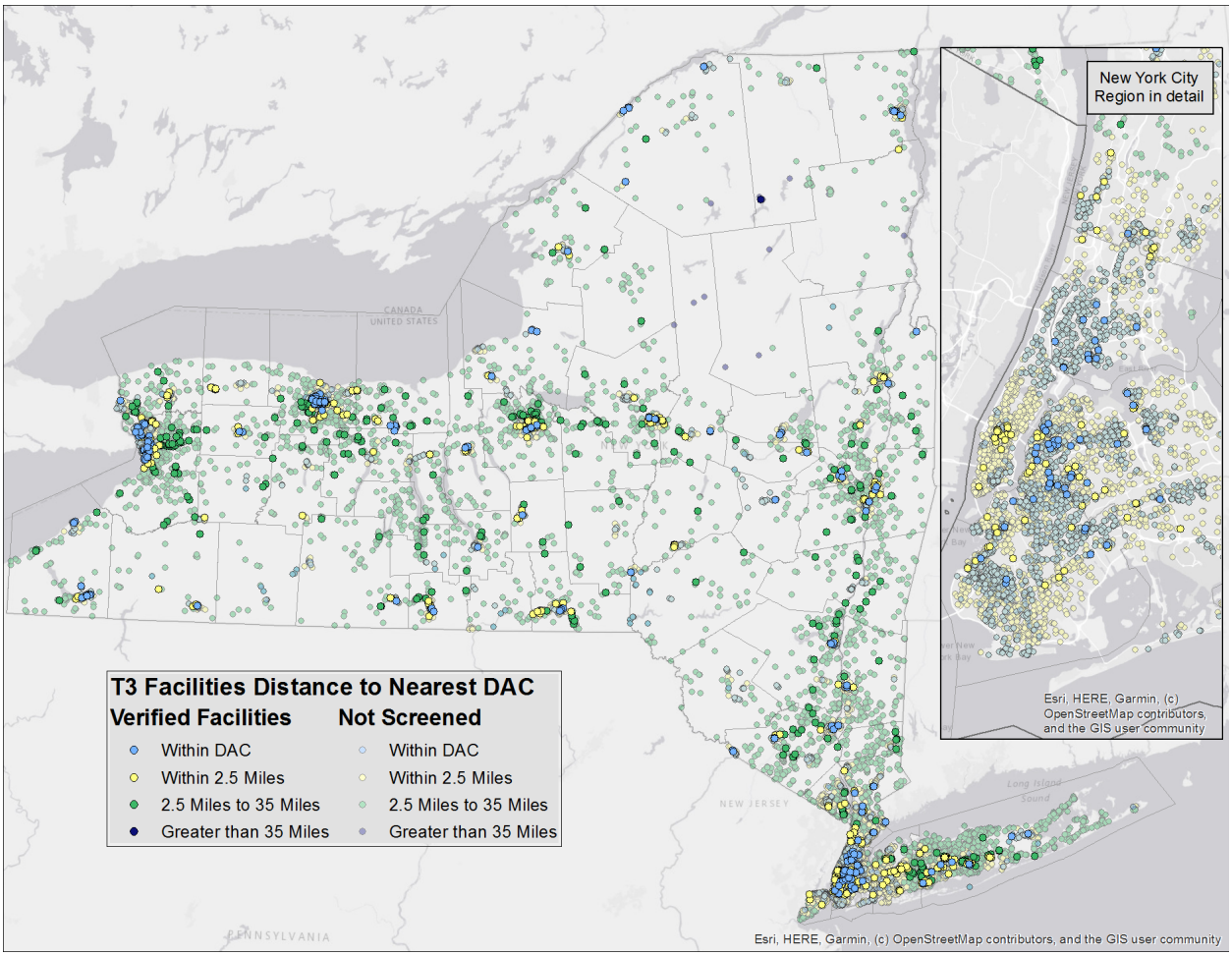


Table 3-37 presents the total number of Tier 3 facilities by the same distance thresholds as those presented for Tiers 1 and 2. Table 3-38 presents Tier 3 total employment by half-mile intervals out to 2.5 miles.

Table 3-37. Number of Tier 3 facilities to nearest DAC

NAICS and Subsector Name	Total Facilities	Distance to nearest DAC				
		Within DAC Border	Within 2.5 Miles of DAC	Between 2.5 Miles and 10 Miles of DAC	Between 10 Miles and 35 Miles of DAC	Outside 35 Miles of DAC or Unmatched Address
339 - Miscellaneous mfg	3,451	762	1,637	886	164	2
311 - Food	3,094	1,021	1,387	528	158	0
332 - Fabricated metal products	2,541	740	923	699	176	3
323 - Printing & related support activities	1,856	501	844	437	73	1
337 - Furniture & related products	1,329	387	589	274	78	1
333 - Machinery	1,017	242	373	323	75	4
312 - Beverage & tobacco products	730	151	197	212	168	2
334 - Computer & electronic products	666	112	278	242	32	2
325 - Chemicals	432	101	193	112	23	3
321 - Wood products	415	79	105	152	76	3
336 - Transportation equipment	374	89	142	112	30	1
315 - Apparel	370	59	284	24	3	0
327 - Nonmetallic mineral products	365	96	142	106	19	2
335 - Electrical equipment, appliance, & component	344	74	138	112	20	0
314 - Textile product mills	335	80	149	86	19	1
326 - Plastics & rubber products	305	95	114	75	20	1
313 - Textile mills	282	66	170	36	10	0
322 - Paper	194	61	72	55	6	0
331 - Primary metals	168	43	71	39	15	0
324 - Petroleum & coal products	81	12	33	29	7	0
316 – Specialty alloys	73	21	47	3	2	0

Table 3-38. Tier 3 total weighted employment to nearest DAC

NAICS and Subsector Name	Total Employment	Distance to nearest DAC				
		Within DAC Border	Within 2.5 Miles of DAC	Between 2.5 Miles and 10 Miles of DAC	Between 10 Miles and 35 Miles of DAC	Outside 35 Miles of DAC or Unmatched Address
332 - Fabricated metal products	33,604	9,970	11,382	10,144	2,076	31
339 - Miscellaneous mfg	33,267	7,127	12,250	12,182	1,590	118
333 - Machinery	17,783	5,236	5,261	5,827	1,255	204
311 - Food	12,300	3,959	4,814	2,688	838	0
334 - Computer & electronic products	10,852	1,878	4,017	3,746	1,196	15
323 - Printing & related support activities	8,894	2,109	3,975	2,429	366	15
337 - Furniture & related products	7,261	1,729	4,011	1,150	369	2
335 - Electrical equipment, appliance, & component	5,272	857	2,127	1,857	430	0
312 - Beverage & tobacco products	4,583	1,040	1,386	1,191	949	17
326 - Plastics & rubber products	3,899	1,051	1,463	1,061	321	3
325 - Chemicals	3,701	834	1,449	1,245	128	45
336 - Transportation equipment	3,030	651	1,095	1,014	265	5
321 - Wood products	3,028	700	563	1,174	575	15
327 - Nonmetallic mineral products	2,921	792	907	1,063	157	2
315 - Apparel	1,957	617	1,045	275	20	0
313 - Textile mills	1,845	438	671	704	32	0
314 - Textile product mills	1,269	472	421	311	64	2
322 - Paper	1,019	285	317	393	23	0
316 – Specialty alloys	910	596	295	7	12	0
331 - Primary metals	848	217	282	262	88	0
324 - Petroleum & coal products	130	19	46	51	14	0

Figure 3-5 provides an overview of the population per square mile in the DAC block groups and the relationship of these block groups to regional bus and subway transit networks per the National Transit Route map layer. Not all bus and other mass transit systems of New York are represented in the National Transit Route database. Hence, this analysis should be seen as a representation of the areas that are

identified in Figure 3-5 rather than as a full accounting of every route in New York State.[34] There is high overlap between the block groups with large concentrations of households below the US Census poverty index and the service regions of the identified mass transit systems as illustrated by the gray areas on the map.

Figure 3-5. DAC block group population below poverty index 2.0 per square mile with public transit 1-mile service buffer

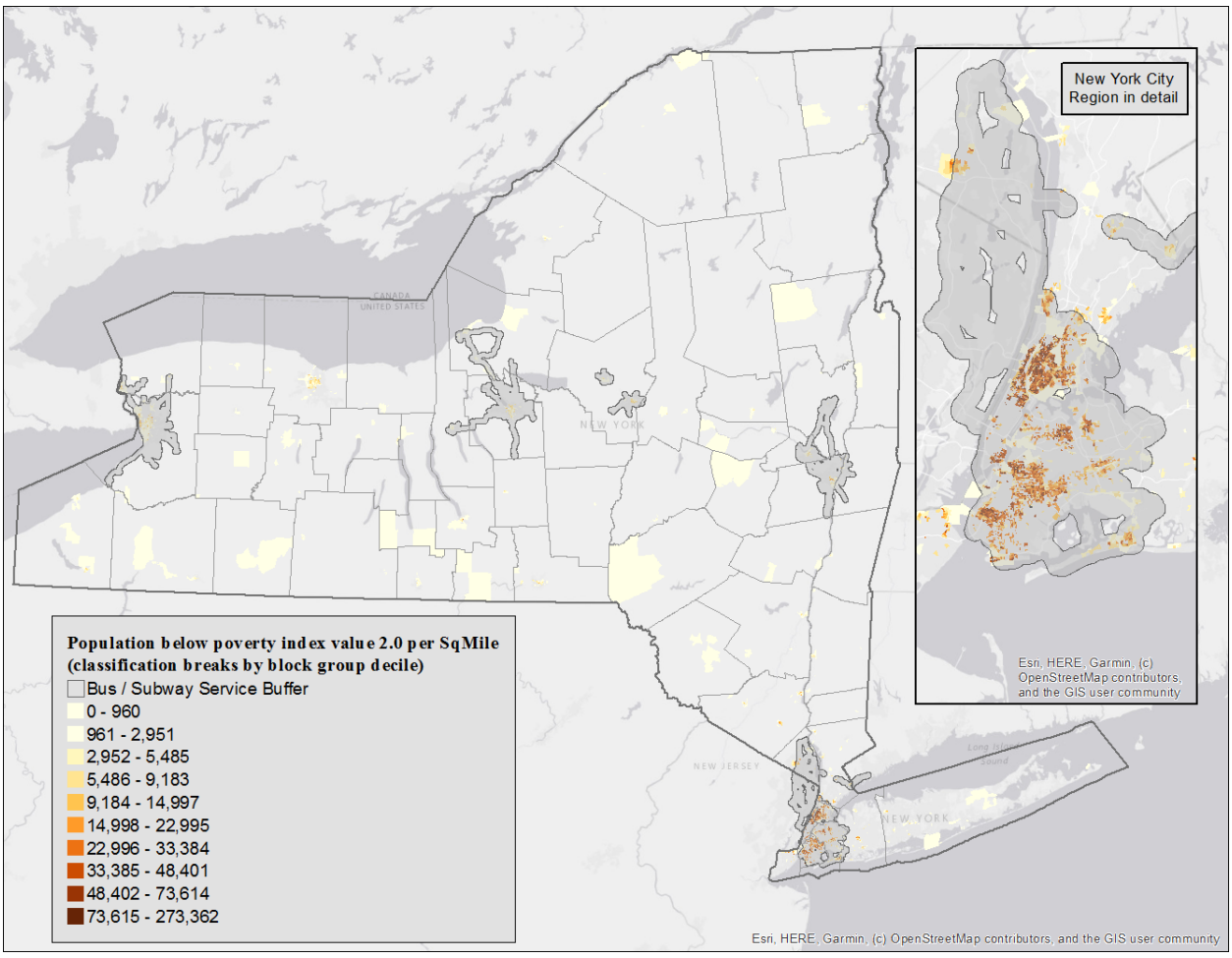


Table 3-39 presents the total number of facilities from Tier 1 and 2 that fall within an identified transit network's 1-mile service buffer. Table 3-40 presents the total employment per the same criteria. While caution should be exercised due to the small population sizes and the incomplete coverage of the mass

[34] The National Transit Route layer collects public data and aggregates this into a spatial file; the reliance on public data means this database is not a fully comprehensive picture of all mass transit options. As an example, the NY Regional Transit Service routes for Rochester, which can be found as a PDF file at https://www.myrts.com/Portals/0/Schedules/RTS%20System%20Map.pdf?ver=2022-06-30-092701-757 is not captured in the National Transit Route layer, and so is not reflected in this analysis.

transit networks, the study team observed that the share of employment identified within the transit network for Electrical Equipment, Appliance, and Component (335) was notably higher than the corresponding share of facilities. This was also true for Nonmetallic Mineral Products (327) and Plastics and Rubber Products (326), though at a lower difference.

Table 3-39. Tier 1 and 2 facilities within 1 mile of transit networks

NAICS and Subsector Name	Within 1 mile of identified mass transit networks	Outside 1 mile of identified mass transit networks	Percent within 1 mile of identified mass transit networks	Percent outside 1 mile of identified mass transit networks
322 - Paper	37	66	35.9%	64.1%
325 - Chemicals	20	41	32.8%	67.2%
331 - Primary metals	22	33	40.0%	60.0%
324 - Petroleum & coal products	16	37	30.2%	69.8%
327 - Nonmetallic mineral products	13	33	28.3%	71.7%
311 - Food	17	23	42.5%	57.5%
334 - Computer & electronic products	9	25	26.5%	73.5%
326 - Plastics & rubber products	9	23	28.1%	71.9%
336 - Transportation equipment	8	19	29.6%	70.4%
312 - Beverage & tobacco products	9	16	36.0%	64.0%
332 - Fabricated metal products	5	15	25.0%	75.0%
339 - Miscellaneous mfg	8	9	47.1%	52.9%
333 - Machinery	5	6	45.5%	54.5%
335 - Electrical equipment, appliance, & component	2	8	20.0%	80.0%
323 - Printing & related support activities	5	3	62.5%	37.5%
321 - Wood products	0	4	0.0%	100.0%
315 - Apparel	1	0	100.0%	0.0%

Table 3-40. Tier 1 and 2 total weighted employment within 1 mile of transit networks

NAICS and Subsector Name	Within 1 mile of identified mass transit networks	Outside 1 mile of identified mass transit networks	Percent within 1 mile of identified mass transit networks	Percent outside 1 mile of identified mass transit networks
334 - Computer & electronic products	3,511	20,738	14.5%	85.5%
336 - Transportation equipment	4,006	12,753	23.9%	76.1%
325 - Chemicals	4,419	9,954	30.7%	69.3%
339 - Miscellaneous mfg	7,700	5,855	56.8%	43.2%
311 - Food	4,111	7,377	35.8%	64.2%
327 - Nonmetallic mineral products	5,388	5,804	48.1%	51.9%
322 - Paper	2,862	8,018	26.3%	73.7%
331 - Primary metals	2,551	5,780	30.6%	69.4%
333 - Machinery	3,712	4,421	45.6%	54.4%
332 - Fabricated metal products	2,000	5,963	25.1%	74.9%
335 - Electrical equipment, appliance, & component	5,000	2,307	68.4%	31.6%
326 - Plastics & rubber products	3,137	3,420	47.8%	52.2%
312 - Beverage & tobacco product	2,310	3,401	40.4%	59.6%
323 - Printing & related support activities	950	1,200	44.2%	55.8%
324 - Petroleum & coal products	318	964	24.8%	75.2%
321 - Wood products	0	1,105	0.0%	100.0%
315 - Apparel	640	0	100.0%	0.0%

Table 3-41 presents the total number of Tier 3 facilities that fall within an identified transit network's 1-mile service buffer. Table 3-42 presents the total employment per the same criteria. As noted earlier, for Tier 3 the geographic analysis is less reliable due to the inability to confirm manufacturing activity for most of these facilities, together with the large number of non-manufacturing facilities likely to be found in and near New York City.

Table 3-41. Total Tier 3 facilities within 1 mile of transit networks

NAICS and Subsector Name	Within 1 mile of identified mass transit networks	Outside 1 mile of identified mass transit networks	Percent within 1 mile of identified mass transit networks	Percent outside 1 mile of identified mass transit networks
311 - Food	1,873	1,221	60.5%	39.5%
339 - Miscellaneous mfg	1,737	1,714	50.3%	49.7%
332 - Fabricated metal products	1,032	1,509	40.6%	59.4%
323 - Printing & related support activities	932	924	50.2%	49.8%
337 - Furniture & related products	663	666	49.9%	50.1%
333 - Machinery	399	618	39.2%	60.8%
312 - Beverage & tobacco product	235	495	32.2%	67.8%
334 - Computer & electronic products	250	416	37.5%	62.5%
325 - Chemicals	196	236	45.4%	54.6%
321 - Wood products	121	294	29.2%	70.8%
336 - Transportation equipment	139	235	37.2%	62.8%
315 - Apparel	318	52	85.9%	14.1%
327 - Nonmetallic mineral products	146	219	40.0%	60.0%
335 - Electrical equipment, appliance, & component	141	203	41.0%	59.0%
314 - Textile product mills	184	151	54.9%	45.1%
326 - Plastics & rubber products	121	184	39.7%	60.3%
313 - Textile mills	193	89	68.4%	31.6%
322 - Paper	98	96	50.5%	49.5%
331 - Primary metals	88	80	52.4%	47.6%
324 - Petroleum & coal products	30	51	37.0%	63.0%
316 – Specialty alloys	55	18	75.3%	24.7%

Table 3-42. Tier 3 weighted employment within 1 mile of transit networks

NAICS and Subsector Name	Within 1 mile of identified mass transit networks	Outside 1 mile of identified mass transit networks	Percent within 1 mile of identified mass transit networks	Percent outside 1 mile of identified mass transit networks
311 - Food	7,138	5,162	58.0%	42.0%
332 - Fabricated metal products	12,037	21,568	35.8%	64.2%
339 - Miscellaneous mfg	13,440	19,827	40.4%	59.6%
333 - Machinery	6,459	11,324	36.3%	63.7%
334 - Computer & electronic products	3,290	7,563	30.3%	69.7%
323 - Printing & related support activities	4,181	4,711	47.0%	53.0%
337 - Furniture & related product	3,146	4,113	43.3%	56.7%
335 - Electrical equipment, appliance, & component	1,784	3,488	33.8%	66.2%
312 - Beverage & tobacco products	1,593	2,990	34.8%	65.2%
326 - Plastics & rubber products	1,133	2,766	29.1%	70.9%
325 - Chemicals	1,265	2,436	34.2%	65.8%
336 - Transportation equipment	638	2,391	21.1%	78.9%
321 - Wood products	701	2,327	23.2%	76.8%
327 - Nonmetallic mineral products	1,052	1,869	36.0%	64.0%
315 - Apparel	1,316	640	67.3%	32.7%
313 - Textile mills	574	1,270	31.1%	68.9%
314 - Textile product mills	567	704	44.6%	55.4%
322 - Paper	304	715	29.8%	70.2%
316 – Specialty alloys	273	637	30.0%	70.0%
331 - Primary metals	295	555	34.7%	65.3%
324 - Petroleum & coal products	41	89	31.5%	68.5%

3.5.2 Manufacturing Emissions Impacting DAC Block Groups

This section documents the manufacturing air emissions of local manufacturing CO_2e emissions in the vicinity of DAC block groups. All maps presented use a three-mile linear (as the crow flies) distance from each facility to determine neighboring geographic areas impacted by local industrial facility emissions. The three-mile linear distance used here is consistent with the that used in the energy Justice Screening Report for the Clean Power Plan Power Plan,[35] which provides detailed demographic information on the communities located within a three-mile radius of each affected power plant within the United States. These graphics provide insight into where site level CO_2e emissions are occurring and the aggregate impact of them on neighboring DACs. In all maps, block groups that are DAC but do not have any emissions are excluded.

The figures below show Tier 1 and 2 (Figure 3-6) and Tier 3 (Figure 3-7) facilities in New York State colored by their site emissions intensity with the aggregate site emissions within each DAC block group. Note that these are estimates imputed based on secondary data, using average subsector emissions per employee to estimate total facility emissions, and not built up from direct information gathered from each facility. Emissions estimates developed for specific facilities may different substantially from these averages. We have distinguished emissions from facilities within a DAC by giving them bolder coloring than emissions from facilities outside of a DAC (which are faded). Note that very few DAC block groups have bolder colors in the Tier 1 and Tier 2 figure, as there are few DACs containing these large manufacturing facilities. Also note that the Tier 3 figure has all Tier 3 facilities in it due to them being unscreened for manufacturing activity.

[35] https://19january2017snapshot.epa.gov/sites/production/files/2016-04/documents/ejscreencpp.pdf

Figure 3-6. Tier 1 and Tier 2 facilities metric tons CO_2e emissions with DAC block group aggregate emissions

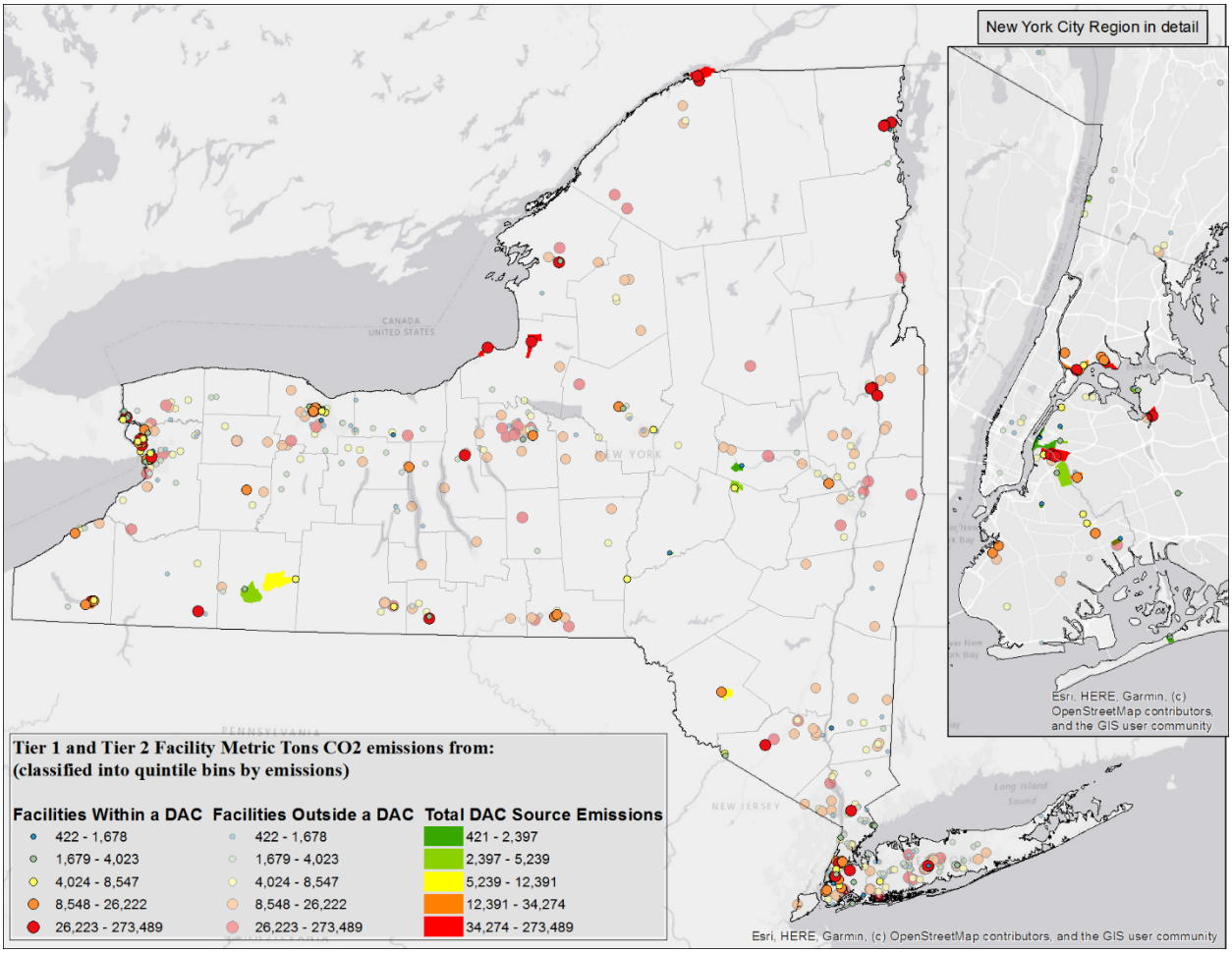
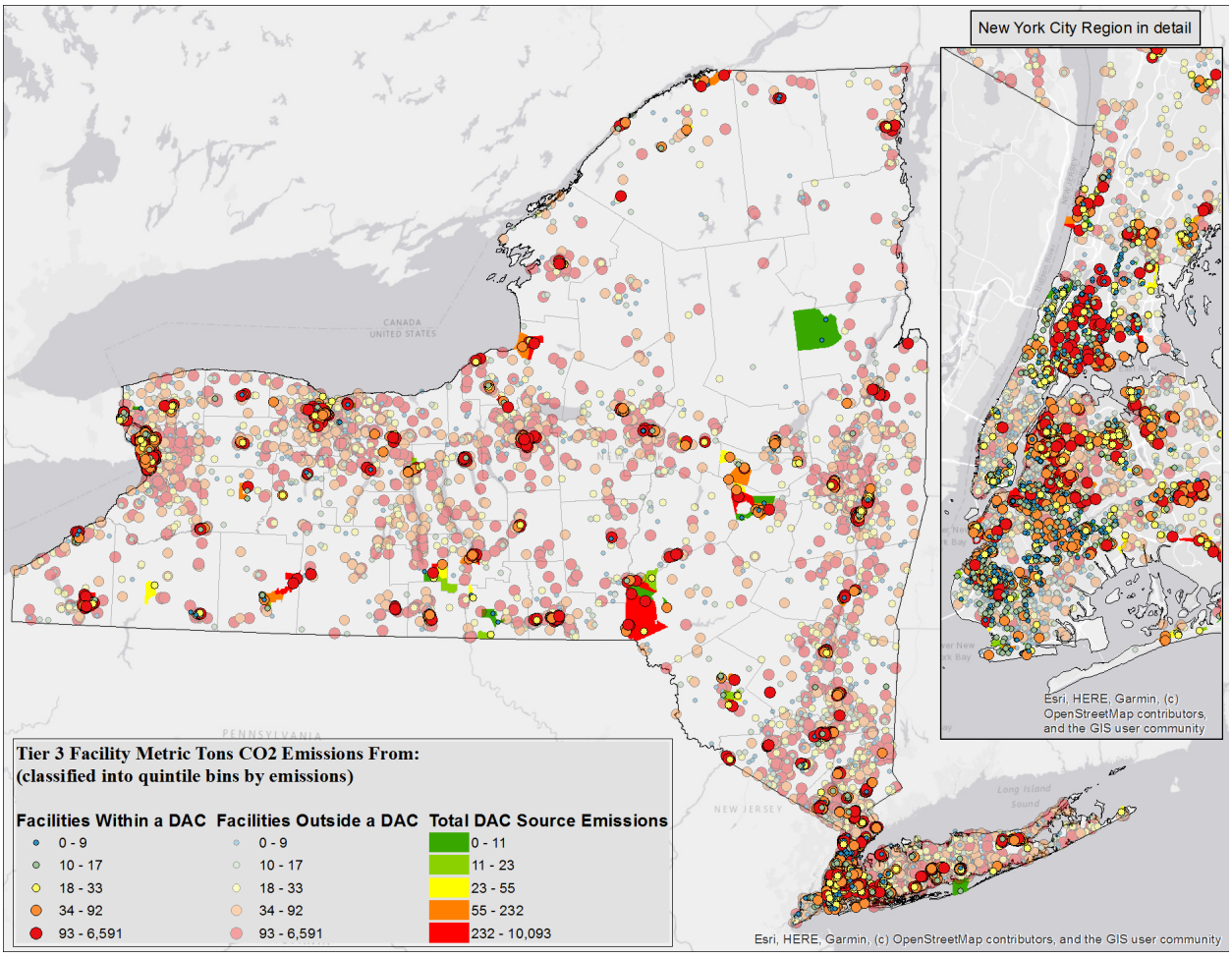


Figure 3-7. Tier 3 facilities metric tons CO_2e emissions with DAC block group aggregate emissions



In the emissions impact maps for Tier 1 and Tier 2 (Figure 3-8) and Tier 3 (Figure 3-9) we show the aggregate CO_2e emissions from industrial facilities that are within three miles of a DAC. The quintile break points[36] used in the legends are set on the full, statewide, facility population. The colored areas represent the geographic area that are within or touching the three-mile emissions radius from the facility source point. In areas where there is only one facility, this results in a three-mile circle where the facility sits in the hexagon at the center of the circle. For areas with multiple facilities with multiple overlapping circles, the result is an irregularly shaped polygon rather than a circle, and the overlapping areas take on the sum of emissions from all contributing three-mile facility emissions buffers. As a visualization example, consider two facilities in a Venn diagram where each facility's two-mile window overlaps to form a figure-eight-shaped polygon; the overlapping part contain the sum of each individual circle's

[36] Quintile breaks sort the data and then split it into 5 equal size groups. This classification system facilitates comparisons between specific data points (such as the facilities or block groups) within the population and provides a sense of scale of differences between data points.

emissions. Emissions that overlap a DAC geography have bolder coloring, while emissions that do not impact DAC geographies have been faded. This allows readers to distinguish between geographies that have high aggregate emissions affecting DACs compared to high aggregate emissions not affecting DACs.

Figure 3-8. Tier 1 and Tier 2 aggregate facility emissions impact on DAC block groups and neighboring areas in metric tons CO_2e

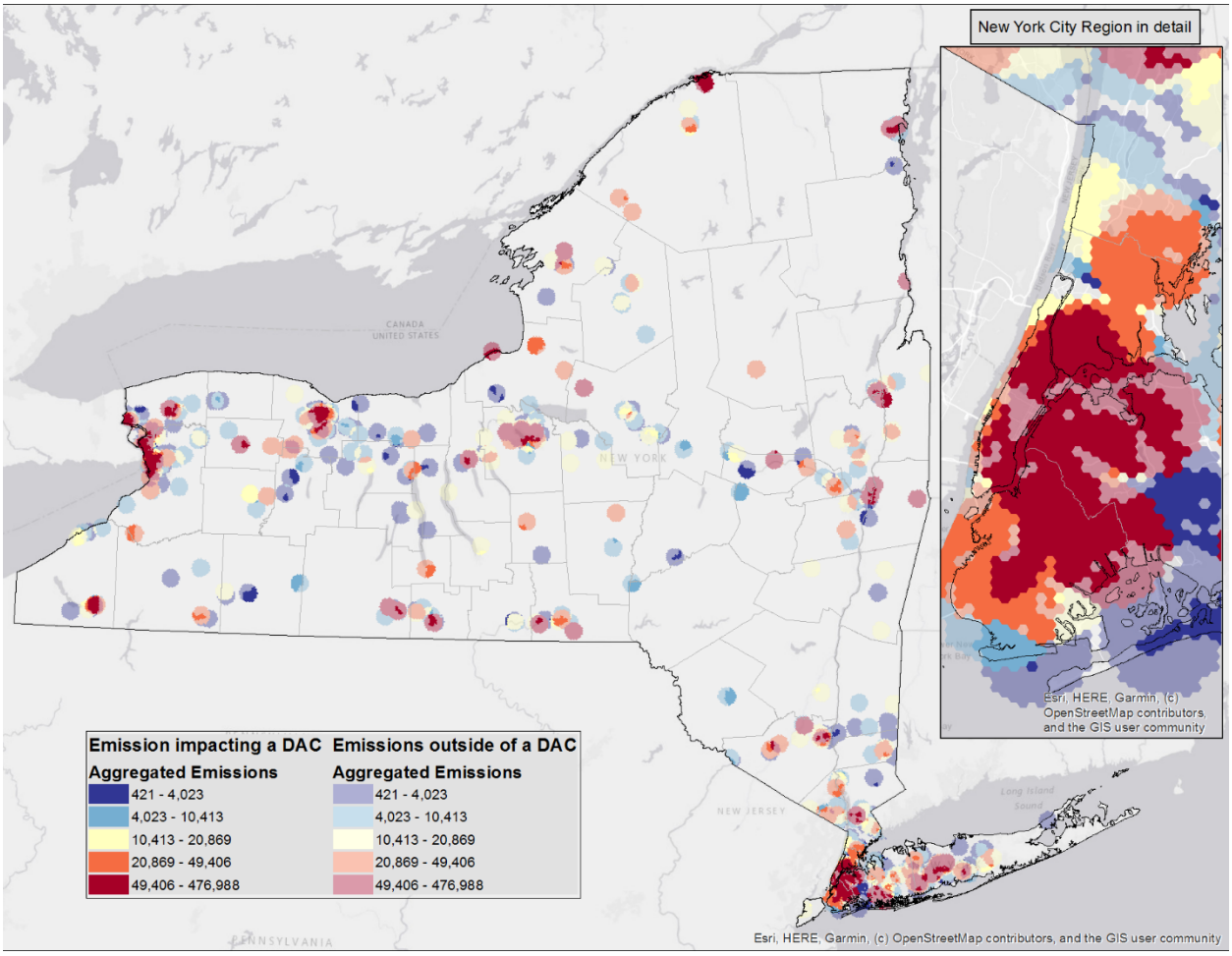


Figure 3-9. Tier 3 aggregate facility emissions impact on DAC block groups and neighboring areas in metric tons CO_2e

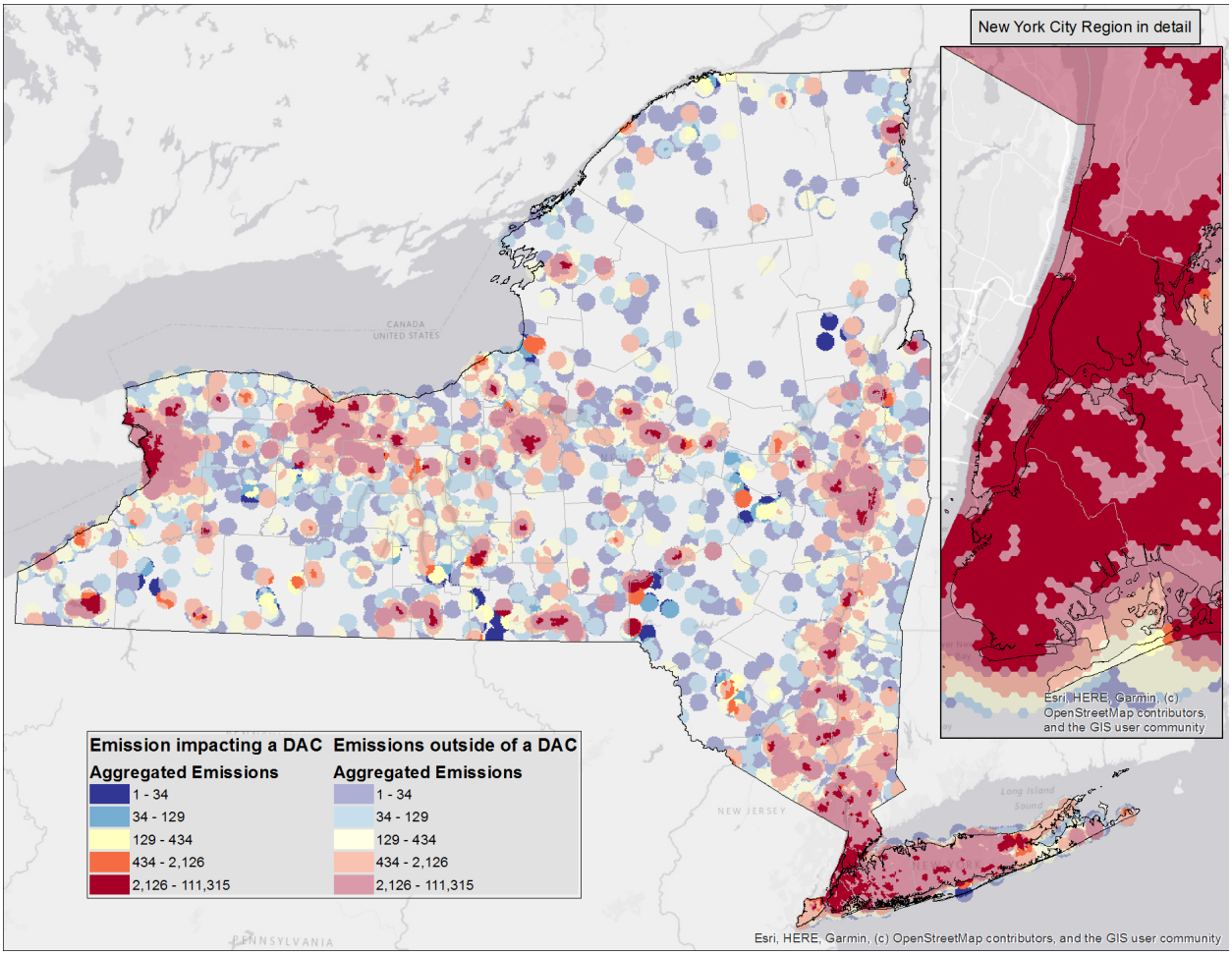


Table 3-43 shows the impact of Tier 1 and Tier 2 facility CO_2e emissions on DAC populations within three miles of them. Like previous results, this table uses the interim definition of DAC from 2020. The leftmost column shows the manufacturing subsector followed by the count of Tier 1 and 2facilities and their local CO_2e emissions total. The fourth column shows the total DAC population exposed to local CO_2e emissions by being within three miles of a Tier 1 or Tier 2 emitting industrial facility. The fifth column shows the number of unique DACs within three miles of any Tier 1 or Tier 2 facility in that subsector. Each DAC can only be counted once in this column if it is within three miles of any facility in that subsector. The final column is the average per-facility emissions-weighted DAC population within three miles of any Tier 1 or Tier 2 facility.

Table 3-43. Tier 1 and Tier 2 local CO_2e emissions impacts on DACs

Row Labels	Tiers 1 and 2 Facility Count	Local Emissions Total ($MTCO_2e$)	Total exposed DAC population within three miles of an emitting industrial facility	Number of unique DACs within three miles of an emitting industrial facility	Average per facility emissions weighted DAC population within three miles of an emitting industrial facility
322 - Paper	102	2,785,062	1,884,780	2,809	28,178
331 – Primary Metals	63	1,418,416	1,807,443	2,653	19,500
324 – Petroleum and Coal Products	52	1,109,243	1,330,666	1,899	31,165
325 - Chemicals	57	543,166	937,443	1,452	11,440
326 - Plastics and Rubber Products	31	26,658	935,293	1,367	58,501
311 - Food	41	124,233	778,172	1,214	19,030
312 - Beverage and Tobacco	26	70,399	601,145	828	23,109
333 - Machinery	10	18,449	561,459	897	63,648
323 – Printing and Related	9	7,000	447,704	679	43,859
336 – Transportation Equipment	27	191,412	399,514	604	9,070
339 - Miscellaneous	17	87,836	376,048	528	18,875
327 - Nonmetallic Mineral Products	41	674,639	324,646	452	63,730
332 – Fabricated Metal Products	20	45,082	250,697	425	13,293
334 – Computer and Electronic Products	26	65,458	197,760	327	5,453
335 - Electrical Equip., Appliances, and Components	10	39,919	52,036	95	11,446
321 - Wood Products	4	66,520	6,739	9	1,220
315 - Apparel	1	-	4,889	11	-
Total	537	7,273,492	2,443,211	3,679	27,749

3.5.3 Industrial Activity within DACs

Industrial activity within a DAC was determined by identifying the spatial relationship between the facilities location data layer and the DAC block group boundary data layer. An important qualifier in this analysis is that the facility must be within the DAC to qualify as "in a DAC," and the geographic size of DACs is highly variable and directly correlated with population. More rural areas tend to have very large block groups with larger DACs by size but fewer DACs in total. Highly urbanized areas like New York City have many small block groups – often on the scale of a single city block – near one another. The implication of this is that the study team is rigidly capturing if a facility is in a DAC block group. Naturally, the benefits (jobs, economic multipliers, etc.) and costs from a facility in a DAC block group (emissions, commuting impact, etc.) are likely to impact neighboring block groups within an x radius.

Table 3-44 shows Tier 1 and Tier 2 facility consumption (MMBtu), emissions (metric tons of CO_2e), and number of facilities in and outside of DACs. This study estimates that roughly a quarter of Tier 1 and Tier 2 facilities are in a DAC. Table 3-45 shows this same information at the manufacturing subsector level.

Table 3-44. DAC Tier 1 and Tier 2 manufacturing facility activity summary

Facility Locations	Facility MMBtu	Metric Tons CO_2e	Facilities
Facilities Within a DAC	41,107,807	2,473,306	139
Facilities Outside a DAC	85,626,776	5,069,550	408
Grand Total	**126,734,584**	**7,542,856**	**547**

Table 3-45. DAC Tier 1 and Tier 2 manufacturing facility activity details

Facility Location and NAICS	Site MMBtu	Metric Tons CO_2e	Facilities
Facilities Inside a DAC	**41,107,807**	**2,473,306**	**139**
322 - Paper	14,124,447	983,667	32
331 - Primary metals	7,524,825	639,610	20
326 - Plastics & rubber products	1,268,996	16,920	14
325 - Chemicals	5,113,487	204,539	14
327 - Nonmetallic mineral products	6,955,641	361,158	10
311 - Food	812,696	27,090	9
324 - Petroleum & coal products	2,116,389	133,425	9
334 - Computer & electronic products	436,898	10,9221	7
336 - Transportation equipment	757,393	32,460	7
333 - Machinery	268,271	8,942	5
312 - Beverage & tobacco products	544,853	16,346	5
332 - Fabricated metal products	193,130	8,277	4
335 - Electrical equipment, appliance, & component	917,760	26,222	1
339 - Miscellaneous mfg	48,600	3,240	1
323 - Printing & related support activities	24,420	488,	1
Facilities Outside a DAC	**85,626,776**	**5,069,550**	**408**
322 - Paper	27,066,244	1,884,971	71
325 - Chemicals	9,342,856	373,714	47
324 - Petroleum & coal products	15,533,556	979,290	44
327 - Nonmetallic mineral products	7,781,911	404,061	36
331 - Primary metals	9,593,908	815,482	35
311 - Food	3,318,621	110,621	31
334 - Computer & electronic products	2,366,284	59,157	27
336 - Transportation equipment	3,708,881	158,952	20
312 - Beverage & tobacco products	1,801,797	54,054	20
326 - Plastics & rubber products	804,957	10,733	18
339 - Miscellaneous mfg	1,268,946	84,596	16
332 - Fabricated metal products	858,782	36,805	16
335 - Electrical equipment, appliance, & component	479,400	13,697	9
323 - Printing & related support activities	325,600	6,512	7
333 - Machinery	311,581	10,386	6
321 - Wood products	1,018,589	66,520	4
315 - Apparel	44,864	0	1
339 - Miscellaneous mfg	48,600	3,240	1
Grand Total	**126,734,584**	**7,542,856**	**547**

Table 3-46 shows Tier 3 facility consumption (MMBtu), emissions (metric tons of CO_2e), and number of facilities in and outside of DACs. The study team includes all Tier 3 facilities in this map, including those that may not be manufacturing, due inability to perform full screening of the Tier 3 population. Similar to the Tier 1 and Tier 2 facilities, this study estimates that roughly 26% of Tier 3 facilities are in a DAC. Table 3-47 shows this same information at the Manufacturing subsector level.

Table 3-46. DAC Tier 3 manufacturing facility activity summary

Facility Locations	Facility MMBtu	Metric Tons CO_2e	Facilities
Facilities Within a DAC	9,882,043	462,475	4,792
Facilities Outside a DAC	29,110,744	1,379,861	13,630
Grand Total	**38,992,787**	**1,842,336**	**18,422**

Table 3-47. DAC Tier 3 manufacturing facility activity details

Facility Location and NAICS	Site MMBtu	Metric Tons CO_2e	Facilities
Facilities Within a DAC	**9,882,043**	**462,475**	**4,792**
311 - Food	1,423,793	47,252	1,021
339 - Miscellaneous mfg	692,709	46,181	762
332 - Fabricated metal products	1,317,039	56,427	740
323 - Printing & related support activities	343,399	6,868	501
337 - Furniture & related product	0	0	387
333 - Machinery	373,344	12,445	242
312 - Beverage & tobacco products	427,210	12,565	151
334 - Computer & electronic products	217,112	5,428	112
325 - Chemicals	839,252	33,570	101
327 - Nonmetallic mineral products	1,042,996	54,003	96
326 - Plastics & rubber products	332,420	4,330	95
336 - Transportation equipment	173,598	7,440	89
314 - Textile product mills	0	0	80
321 - Wood products	645,406	42,149	79
335 - Electrical equipment, appliance, & component	163,947	4,684	74
313 - Textile mills	0	0	66
322 - Paper	1,079,766	75,198	61
315 - Apparel	43,272	0	59
331 - Primary metals	445,048	37,829	43
316 – Specialty alloys	66,255	0	21
324 - Petroleum & coal products	255,475	16,106	12

Facility Location and NAICS	Site MMBtu	Metric Tons CO_2e	Facilities
Facilities Outside a DAC	**29,110,744**	**1,379,861**	**13,630**
339 - Miscellaneous mfg	2,540,824	167,874	2,689
311 - Food	2,999,405	98,861	2,073
332 - Fabricated metal products	3,121,989	133,390	1,801
323 - Printing & related support activities	1,104,484	22,041	1,355
337 - Furniture & related product	0	0	942
333 - Machinery	894,603	28,914	775
312 - Beverage & tobacco products	1,455,875	43,085	579
334 - Computer & electronic products	1,037,435	25,678	554
321 - Wood products	2,145,562	140,118	336
325 - Chemicals	2,883,332	111,376	331
315 - Apparel	93,879	0	311
336 - Transportation equipment	633,932	26,927	285
335 - Electrical equipment, appliance, & component	844,049	23,947	270
327 - Nonmetallic mineral products	2,803,905	144,762	269
314 - Textile product mills	0	0	255
313 - Textile mills	0	0	216
326 - Plastics & rubber products	900,696	12,009	210
322 - Paper	2,777,021	193,400	133
331 - Primary metals	1,298,159	110,344	125
324 - Petroleum & coal products	1,540,729	97,133	69
316 – Specialty alloys	34,866	0	52
Grand Total	**38,992,787**	**1,842,336**	**18,422**

3.6 Greenhouses

As stated in Section 2.7, the study team was unsuccessful in identifying resources to develop greenhouse characteristics, such as facility employment, energy consumption, energy expenditures, sales, or greenhouse gas emissions. New York State requires greenhouses to be licensed, and that registry provides a very reliable population that includes contact information (owner), company name, company contact, and phone numbers. Table 3-48 summarizes greenhouses on that registry by size (square feet of glass). Roughly 12% of greenhouses have more than 20,000 square feet of structure glass, with the balance divided near evenly at above and below 2,000 square feet.

Table 3-48. Greenhouse population summary by size (sq ft glass)

Square feet of glass	Number of facilities	% of facilities
20,001 sq ft of glass or more	233	12%
2,001-20,000 sq ft of glass	849	43%
2,000 sq ft of glass or less	873	44%
Unknown	25	1%
Total	**1,980**	**44%**

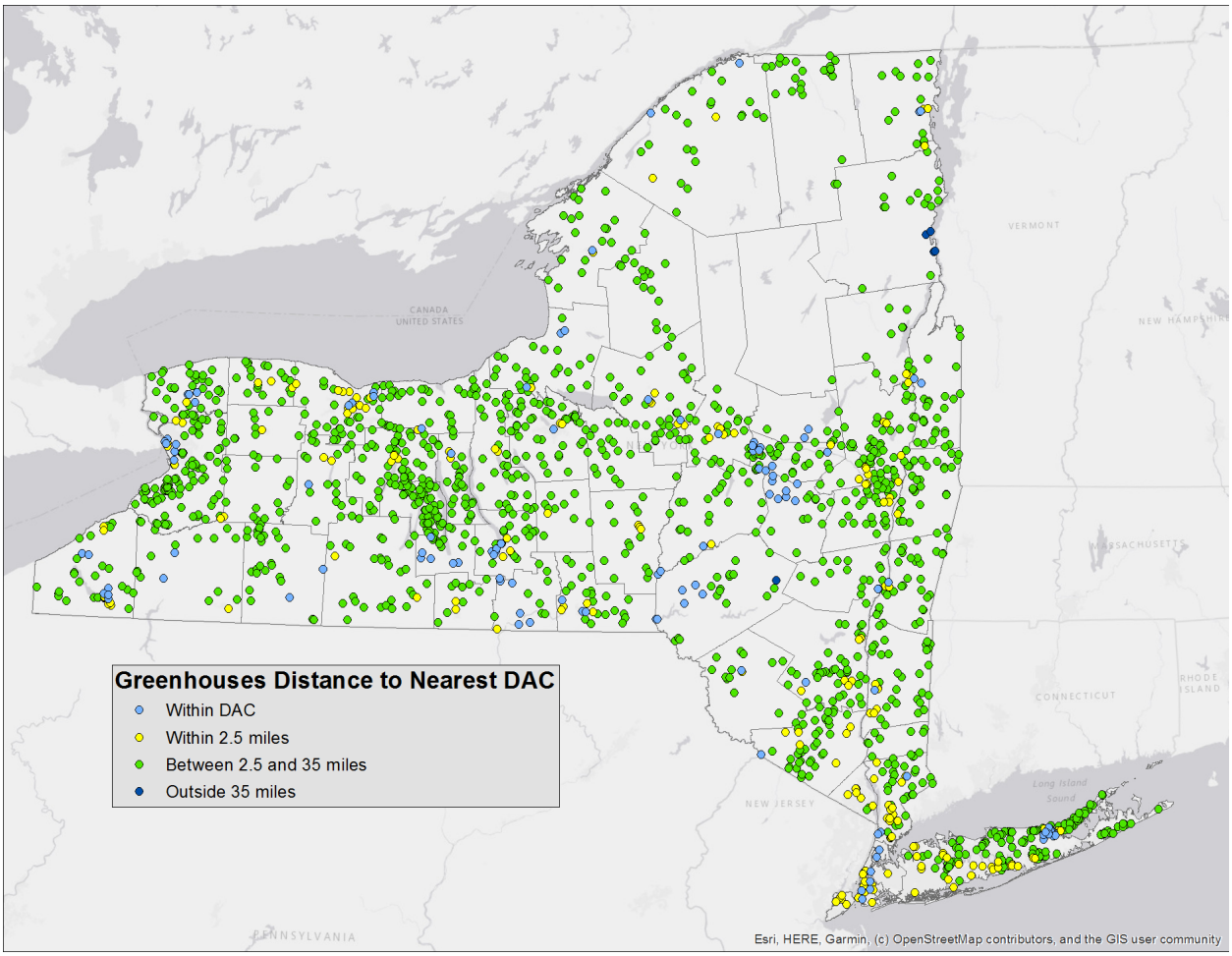
The team geocoded the greenhouses by address to provide a spatial analysis like that presented by the manufacturing subsector above. Table 3-49 presents the proximity relationship of identified greenhouse facilities relative to the nearest DAC; Figure 3-10 presents the locations of the listed greenhouses. Employment totals are not included in this table due to lack of available data. The majority of greenhouses (60%) are located within 10 miles from DACs.

Table 3-49. Relationship between greenhouse facilities and DACs

NAICS and Subsector Name	Total Employment	Distance to nearest DAC				
		Within DAC Border	Within 2.5 Miles of DAC	Between 2.5 Miles and 10 Miles of DAC	Between 10 Miles and 35 Miles of DAC	Outside 35 Miles of DAC or Unmatched Address
334 - Computer & electronic products	24,249	3,779	4,834	15,636	0	0
336 - Transportation equipment	16,759	2,842	8,304	4,903	710	0
325 - Chemicals	14,373	5,084	2,480	5,901	360	548
339 - Miscellaneous mfg	13,555	500	5,721	6,934	400	0
311 - Food	11,489	2,260	4,981	1,476	1,647	1,124
327 - Nonmetallic mineral products	11,192	5,282	2,274	2,404	1,015	217
322 - Paper	10,881	3,731	2,679	2,434	1,612	424
331 - Primary metals	8,332	3,662	1,363	1,830	1,116	360
333 - Machinery	8,133	3,763	2,370	1,500	500	0
332 - Fabricated metal products	7,963	1,462	4,210	1,051	1,240	0
335 - Electrical equipment, appliance, & component	7,307	4,800	1,662	615	230	0
326 - Plastics & rubber products	6,557	4,012	904	1,070	335	236
312 - Beverage & tobacco products	5,711	1,326	1,605	2,690	90	0
323 - Printing & related support activities	2,150	150	1,300	700	0	0
324 - Petroleum & coal products	1,282	154	664	406	58	0
321 - Wood products	1,105	0	200	615	290	0
315 - Apparel	640	0	640	0	0	0

Square feet of glass	Total Facilities	Distance to nearest DAC				
		Within DAC Border	Within 2.5 Miles of DAC	Between 2.5 Miles and 10 Miles of DAC	Between 10 Miles and 35 Miles of DAC	Outside 35 Miles of DAC or Unmatched Address
2,000 SqFt of Glass or Less	885	64	84	349	303	85
2,001-20,000 SqFt of Glass	850	52	79	393	262	64
20,001 SqFt of Glass or More	234	11	34	119	47	23
Total	**1,969**	**127**	**197**	**861**	**612**	**172**

Figure 3-10. Greenhouse facility locations by distance to nearest DAC



4 Recommendations for Phase Two Sector Targeting

The two-phase New York State Industrial Facility Stock Study will characterize the New York industrial subsectors and the greenhouse sector to establish a baseline understanding of New York State's industrial facility stock across key subsectors and the clean energy improvements that have been made in these subsectors. This baseline will be used in future efforts to estimate the potential opportunity for clean energy in New York industrial facilities and to track market progress in the achievement of New York State's CLCPA goals. Phase One uses secondary research to characterize manufacturing subsectors as part of the baseline effort as well as to help identify subsectors that may harbor significant clean energy potential and be prioritized for primary data collection in Phase Two.

Phase Two will include online or phone surveys with a sample of approximately 1,365 facilities, with virtual or physical onsite inspections for a subsample of approximately 275 facilities. Phase Two will address all manufacturing subsectors with sector-level precision targets for targeted manufacturing subsectors, as well as for greenhouses.

Table 4-1 shows a recommended list of key manufacturing subsectors for Phase Two research, along with the estimated number of manufacturing locations, key metric results, and their final weighted rank as discussed in Section 2.5. These key subsectors represent 45% of all estimated manufacturing facilities in New York state, 56% of estimated manufacturing employment, 87% of estimated manufacturing energy consumption, and 84% of manufacturing CO_2e emissions. As described earlier, the blended metric rank column shows the weighted average of subsector ranks across the five key sets of results shown.

Table 4-1. Recommended Phase Two sector targets with key metric and blended overall metric ranks

NAIS and Manufacturing Subsector	Number of Facilities (N)	Total Consumption (MMBtu)	Total Employment (N)	Total Emissions ($MTCO_2e$)	Total Value of Shipments ($)	Total Energy Expenditures ($)	Blended Metric Rank
322 Paper mfg	213	45,047,478	11,899	3,700,329	8,044,193	223,586,435	2.9
325 Chemical mfg	328	18,178,927	18,074	1,454,314	12,119,285	175,649,366	3.5
311 Food mfg	1,228	8,554,515	23,789	760,401	9,505,016	107,617,905	5.4
331 Primary metal mfg	150	18,861,941	9,180	2,357,743	4,715,485	167,538,413	5.6
324 Petroleum and Coal Products	98	19,446,149	1,413	1,395,050	4,227,424	200,576,631	6.5
334 Computer & electronic product mfg	435	4,057,729	35,101	405,773	10,144,323	89,975,738	6.7
332 Fabricated metal product mfg	1,961	5,490,940	41,567	705,978	7,844,201	89,764,940	6.8
327 Nonmetallic mineral product mfg	304	18,584,453	14,113	1,393,834	3,573,933	165,654,015	7.2
336 Transportation Equipment	218	5,273,803	19,789	226,020	7,534,004	72,127,013	9.1
Total manufacturing proposed key targets	**4,935**	**143,495,935**	**174,925**	**12,399,442**	**67,707,864**	**1,292,490,456**	**N/A**
Total manufacturing proposed non-key targets	**6,086**	**22,231,435**	**135,125**	**2,309,101**	**38,027,284**	**320,241,981**	**N/A**

Appendix A: Program Data

This study used information from the IPE Program. This program was administered by NYSERDA and provides energy efficiency assistance to manufacturers and data centers and has been closed to new applications since December 2019. This source provided completed project participant company name and county (not address) that was used as part of screening facilities for manufacturing activity.

Appendix B: Prior Industrial Studies

Two previous NYSERDA commissioned industrial efforts were used as part of this study. These are summarized in the sources section of this report and are further detailed below.

- **Continuous Energy Improvement Market Evaluation and (CEI) Data.** [37] NYSERDA has regularly performed primary data collection as part of market studies to support the CEI program in 2017, 2019, and 2021. The studies included screening of all Tier 1 and Tier 2 facilities and samples of Tier 3 facilities, to identify facilities with manufacturing activity in addition to energy management practices and other market process indicators. The CEI data was used as a primary source to screen non-manufacturing locations from the population (Data Axle), as well as identifying energy management culture and practices, and contact information.
- **Manufacturing improvement fact sheets.** NYSERDA has published fact sheets that capture typical manufacturing processes and clean energy opportunities (e.g., efficiency) for the largest manufacturer sectors in the state. The study team acquired updated fact sheets through NYSERDA as part of this study, including two found online.[38,39] These sheets provided key information on typical energy use, production/ process equipment and improvements opportunities for nine three-digit NAICS codes. A summary of this information is provided in Appendix E.

[37] Continuous Energy Improvement Market Evaluation 2019 Final Report, NYSERDA, Prepared by Cadmus and APPRISE, April 2020

[38] https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Fact-Sheets/Industrial/food-processing-fs.pdf

[39] https://www.google.com/url?client=internal-element-cse&cx=018067764286465601005:6kze-mifwrc&q=https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Fact-Sheets/Industrial/paper-manufacturing-fs.pdf&sa=U&ved=2ahUKEwj0t_a4-Z75AhXgKlkFHfyuBp8QFnoECAUQAQ&usg=AOvVaw13wowOL3MzH4uOmpzXD9fi

Appendix C: Utility Energy Usage Data

Phase One of this study did not use utility energy usage data. It did use consumption estimates from MECs in several calculations. Phase Two will incorporate utility consumption obtained from utility bills provided by industrial facility managers or obtained from utilities with customer data consent releases.

Appendix D: Data Framework

This project has aggregated all identified industrial facilities into a SAS dataset with screening results, location information, and imputed facility-level variables (e.g., energy consumption, square footage) for use in future analysis. A list of the captured attributes and their definitions are provided in Table 4-2 in alphabetical order.

This data framework allows for future additions of both additional facilities and additional attributes. If potential additional manufacturing facilities are identified, they will be appended on to the existing data structure, with the new record checked to determine if any duplicate exists by address and facility name. If a duplicate does exist, the attributes for the two records would be compared to see which appears to contain the most recent or most accurate information. Once that determination is made, only the most recent or accurate information will be retained.

Table 4-2. Data framework variable definitions

Attribute	Type	Definition
Collapsed_Disposition	String	Indicator of whether a site was confirmed to have manufacturing activity or if the site was unscreened.
Company_Name	String	Site company name as provided by data source
Cons_Per_Dol_Val_Thousand_BTU	Float	Site consumption of energy per dollar of value added in thousand BTUs
Cons_Per_Empl_Million_BTU	Float	Site consumption of energy per employee in million BTUs
Contact_Gender	String	Site contact gender as provided by data source
Contact_Name	String	Contact name as provided by data source
Contact_Phone_Number	Float	Site contact phone number as provided by data source
Contact_Salutation	String	Site contact salutation as provided by data source
Contact_Title	String	Site contact title as provided by data source
Dollar_Value_Of_Shipments	Float	Site dollar value of shipments
Establishment_Weight	Float	Site weight, used when summarizing site attributes to the population level
Fuel_Expense_Dollars	Float	Site fuel expenditures
Fuel_Expense_Tier	String	Site tier based on fuel expenditures
Full_Disposition	String	Indicator of the method used to screen a site and whether or not it was confirmed to have manufacturing activity
Greenhouse_License_Number	String	New York State license number for greenhouse facilities
Greenhouse_Size	String	Greenhouse size in binned square feet of glass
KG_CO2_Per_Dollar_Of_Shipments	Float	Site kg of CO2 produced per dollar value of shipments
Latitude	Float	Site latitude as provided by data source or filled by geocoding site address
Location_Employment	Float	Site number of employees as provided by data source
Location_Sales	Float	Site sales as provided by data source
Longitude	Float	Site longitude as provided by data source or filled by geocoding site address
NAICS_Code	Float	Six-digit site NAICS code as provided by data source or manually filled in when missing
NAICS_Desc	String	Text description of the NAICS_Code field
Site_Address	String	Site address as provided by data source

Attribute	Type	Definition
Site_City	String	Site city as provided by data source
Site_County	String	Site county as provided by data source
Site_ID	String	Unique identifier of the site in the data structure
Site_State	String	Site state as provided by data source
Site_Zip_Code	Float	Site zip code as provided by data source
Source	String	Source of the data: Data Axle, Flight, Dodge, or NYS Greenhouse
Total_Consumption_BTU	Float	Total site energy consumption in BTUs
Total_Electric_Consumption_BTU	Float	Site total electric consumption in BTUs
Total_Gas_Consumption_BTU	Float	Site total gas consumption in BTUs
Total_Square_Feet	Float	Site square footage
Web_Site	String	Company web site as provided by data source

Appendix E: Key Manufacturing Subsector Target Measures and Disaggregated Consumption

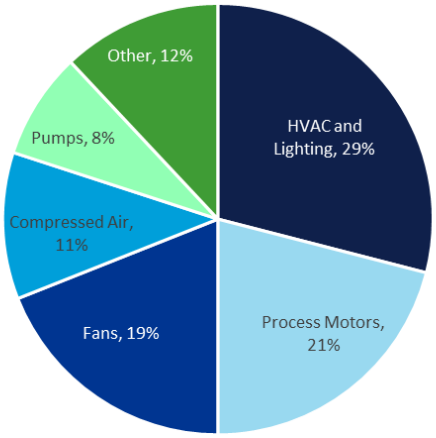
This appendix provides information on energy consumption and energy efficiency measures in the eight key subsectors previously identified by NYSERDA as well as some information on the energy use breakdowns for each subsector. The foundations of this section are the manufacturing information sheets developed by NYSERDA, with information added from other studies and sources by subsector. As noted in Section 3.3.1, these eight subsectors are likely candidates for targeting in the primary research in Phase Two. Phase Two data collection will consider those processes presented in this section for direct observation and deeper examination.

Fabricated Metals (NAICS 332)

Fabricated metal manufacturing generally includes manipulation of raw material and, in some cases, a finish. That manipulation includes processes for cutting or laser cutting, shaping, welding, grinding, stamping, etching, and spinning, while the finish can include coating, painting, or polishing.

In the fabricated metals subsector, the most electricity-consuming equipment are HVAC, lighting, process motors, and fans. There is the potential for additional thermal energy usage onsite as well; however, Figure 4-1 and Table 4-3 for fabricated metal manufacturing are focused on electric consumption. Figure 4-1 is a breakdown of the electric end uses in a structural metal products plant per a 2010 analysis performed by DeWahl, Karl et al.[40]

Figure 4-1. Electric distribution in structural metal products plant (NAICS 325)



[40] DeWahl, Karl et al. "Energy Conservation Market Analysis." University of Minnesota: Minnesota Technical Assistance Program. 2010

A summary of some target electric energy efficiency actions typically available in in metal fabrication facilities are listed in Table 4-3.

Table 4-3. Electric improvement opportunities, Fabricated Metals[41] (NAICS 332)

Process Step	Target Action	Purpose	Energy Savings
Motors/pumps/fans	Variable speed drives	Better match motor/pump speed to the application	4%–5% energy savings
	Install high-efficiency models	Reduce energy consumption on units that are in use the most	12%–20% energy savings
Compressed air	Supply-side analysis	Increase the efficiency of the compressed air system	Depends on the action item
	Demand-side analysis	Decrease the demand for compressed air	Depends on the action item
Welding	Invest in more efficient welder models	New models have inverters rather than transformers, and can auto adjust to optimize performance	20% energy savings

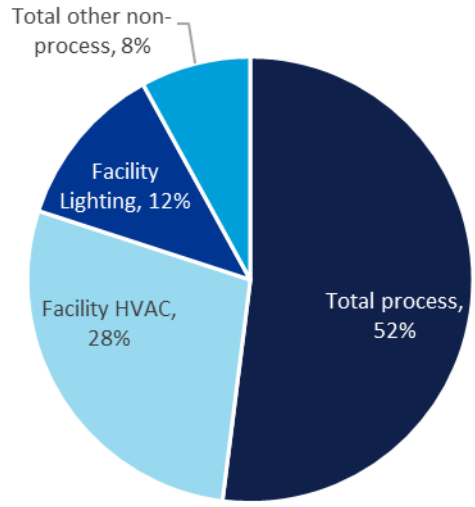
Computers and Electronics (NAICS 334)

A rapidly growing manufacturing sector, computer and electronic manufacturing is also extremely energy intensive. Many electronic devices will consume more energy being produced than over the entire remainder of their lifecycles.[42] The most electricity-consuming equipment in this sector is semiconductor manufacturing, computer assembly, and silicon wafer manufacturing. HVAC is particularly intensive in the computer and electronic subsector, as the clean rooms where semiconductor manufacturing occurs require specific temperatures and levels of air purity. A breakdown of the process and non-process energy consumption for a typical electronics manufacturer is shown in Figure 4-2.

[41] Improving Industrial Efficiency: Fabricated Metal Manufacturing, NYSERDA Fact Sheet

[42] Williams, E. (2004) Energy Intensity of Computer Manufacturing: Hybrid Assessment Combining Process and Economic Input-Output Methods. Journal of Environmental Science and Technology. No. 38, pp. 6166-6174

Figure 4-2. Electric distribution in computer and electronics manufacturing (NAICS 334)



A summary of typical energy efficiency actions in computer and electronics facilities is provided in Table 4-4. These opportunities are primarily electric; however, the HVAC optimization could apply to gas as well.

Table 4-4. Energy improvement opportunities, Computers and Electronics[43] (NAICS 334)

Process Step	Target Action	Purpose	Sample Energy Savings
Semiconductor manufacturing	Install idle-mode capability in process equipment	Reduce electrical demand when production is not occurring	Depends on operating patterns, vintage of equipment.
	Upgrade pumps with high-efficiency motors	Reduce electrical demand during production	Taken together, 62% average demand reduction per pump
	Increase cooling water temp. rises; add VFDs	Reduce required flow rates and electrical demand	
Non-process building support systems	Optimize HVAC systems	Achieve desired air purity with less air turnover, lower air velocity	40-50% average reduction in HVAC energy usage
	Retrofit lighting systems	Reduce demand with more efficient fixtures and better lighting controls	Depends on existing lighting. Maybe 10-30% reduction in lighting energy

A CPUC study[44] of the computer and electronic subsector found a major barrier to the acceptance of optimizing the ventilation system with VFDs in clean rooms was concern over degradation of clean room

[43] Improving Industrial Efficiency: Computers and Electronics, NYSERDA Fact Sheet

[44] CPUC Industrial/Agricultural Market Saturation Study; 2021 Potential and Goals Study, DNV GL and Guidehouse, February 9, 2021.

integrity. An alternative way to improve ventilation fans in clean rooms beside VFDs is the use of HEPA filters in low pressure drop systems. These filters have higher capacities for collecting particles for longer periods of time, resulting in less fan energy use for the same airflow rate. Roughly 36%-39% of clean room spaces were estimated to have low-pressure drop HEPS filters in the California study.

Plastics and Rubber Manufacturing (NAICS 326)

Plastics and rubber manufacturing generally use similar process steps to achieve their end products. These include the addition of additives, molding and/or extruding, cutting, trimming, and possibly coating the final product. In New York State, approximately 14% of the facilities in NAICS code 326 are rubber manufacturers with the other 86% being plastic manufacturers, according to the Hoover's Company Database. The most electricity-consuming equipment in this sector is machine drives, process heating, and HVAC. A breakdown of those end uses can be seen in Figure 4-3.

Figure 4-3. Electric distribution in plastics plant (NAICS 326)

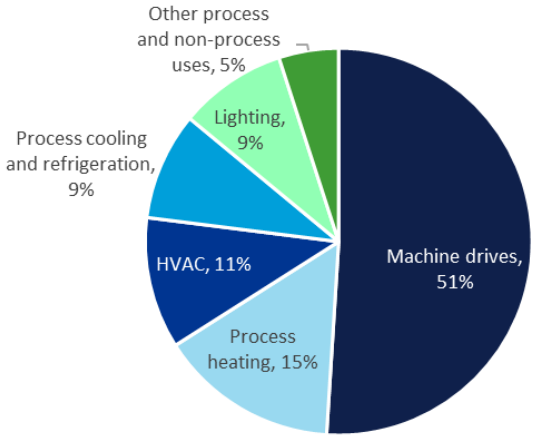


Table 4-5 provides a summary of target energy efficiency actions within the plastics and rubber manufacturing sector.

Table 4-5. Energy improvement opportunities, Plastics and Rubber manufacturing[45] (NAICS 326)

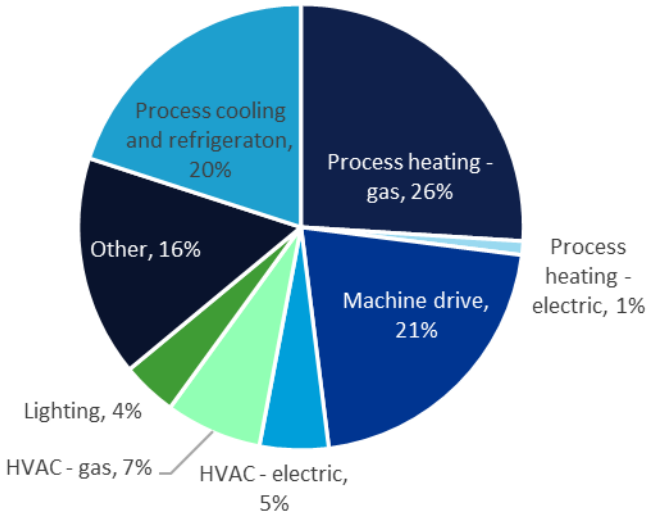
Process Step	Target Action	Purpose	Energy Savings
Motors/pumps	Variable frequency drives	Better match motor to load (<50% oversized)	Save 7%–60% of the existing energy costs
	Install premium efficiency motors	Reduce elect consumption	Will depend on the efficiency of the unit being replaced
	Install smaller motors	Better match motor to load (>50% oversized)	Varies; but can save over 15% of energy costs
Compressed air	Supply-side analysis	Increase the efficiency of the compressed air system	Depends on the target action
	Demand-side analysis	Reduce the demand for compressed air	Depends on the target action
Process heating	Insulate equipment	Reduce radiant heat loss	Case studies show potential paybacks ranging from 1 to 7 months
Auxiliary equipment	Install electricity monitoring software	Reduce electricity consumption of aux. equipment when main processes are not in use	Varies, but could save 10% or more of auxiliary equipment energy costs

Food Manufacturing (NAICS 311)

Food manufacturing generally transforms livestock and agricultural products into products for intermediate or final consumption. The processes in this sector can include grain processing, animal slaughter and processing, and fruit processing, among others. While the end products vary, there are similarities in the requirements for food handling, such as preservation, sterilization, and packaging. The most electricity-consuming equipment in this sector is motors, pumps, refrigeration, compressed air, and boilers. An example of an energy use breakdown at a dairy plant can be seen in Figure 4-4.

[45] Improving Industrial Efficiency: Plastics and Rubber Manufacturing, NYSERDA Fact Sheet

Figure 4-4. Energy distribution in dairy manufacturing facility (NAICS 311)



A summary of cross-cutting widely applicable energy efficiency opportunities in food manufacturing from the New York State Manufacturing Fact Sheets can be seen in Table 4-6.

Table 4-6. Energy improvement opportunities, Food manufacturing – Cross-cutting[46] (NAICS 311)

Process Step	Target Action	Purpose	Energy Savings
Motors/pumps	Variable speed drives	Better match motor/pump speed to the application	7%–60%
Pumps	Install holding tanks and eliminate redundant liquid flows	Reduce pump demand	10%–40%
Refrigeration/freezing	Ambient cooling	Use ambient air during winter months to reduce active chilling	Up to 15%
	Insulate refrigerated areas	Reduce the refrigeration requirement	Depends on the existing facility
	Increase refrigerated temps	Ensure cooling areas are not cooled more than what is truly needed	1%–3% for each °F increase
Compressed air	Leak reduction (check for leaks)	Increase efficiency of compressed air system	10%-20%
Boiler system	Boiler shell insulation improvement and heater circuit controls	Minimize shell loss while maintaining output temperature range.	6%-26% (combined)
	Boiler economizers	Use flue gases to preheat boiler feedwater	5%-10%

[46] Improving Industrial Efficiency: Food Manufacturing, NYSERDA Fact Sheet

Process Step	Target Action	Purpose	Energy Savings
	Direct contact water heaters	More efficient water heating	22%
Steam distribution systems	Improved insulation	Reduce distribution system heat loss	4%-13%
	Leak repair	Reduce heat losses through the system	5%-10%
	Steam trap maintenance & monitoring	Replace malfunctioning steam traps and implement automated monitoring	10%-15%

A summary of process-specific energy efficiency actions for food manufacturing can be seen in Table 4-7.

Table 4-7. Energy improvement opportunities, Food manufacturing – Process energy-specific[47] (NAICS 311)

Process Step	Target Action	Purpose	Energy Savings
Process heat recovery	Heat recovery from a variety of processes, such as blanching water, product drying, pasteurization, steam peeling, and fryer exhaust	Use recovered heat to pre- heat air or water to be used for equipment cleaning, boiler feedwater, or process fluids	Depends on the existing facility and the processes used. Heat recovery from fryer can supply 10% of energy needed to fryer
Pasteurization and sterilization	Compact immersion tube heat exchangers	Use natural gas directly to generate heat for process	Estimated savings up to 35% compared to central water heating
	Induction heating of liquids	Targeted electrical-based heating	Estimated savings up to 17% compared to boiler-based heating
	Pulsed electric field pasteurization	Lower temperature process which reduces cooling energy needs	Varies
Evaporators	Multiple effect evaporators	Increase amount of water evaporated per pound of steam	Estimated 25% steam savings per effect
	Vapor recompression	Use compressed vapors from evaporator as heating medium	Varies. Thermal vapor recompression is more efficient than mechanical vapor recompression

[47] Improving Industrial Efficiency: Food Manufacturing (Updated), NYSERDA Fact Sheet

Process Step	Target Action	Purpose	Energy Savings
Drying	Direct-fired dryers	Increase efficiencies by using fuel directly	Savings of 35%-45% relative to steam heating
	Multiple stage drying	Increase efficiency of drying system relative to spray dryers	Up to 10% of steam usage
	Heat pump drying	Effective use of low temperature waste heat	Varies. Requires energy input but still less intensive overall.
Refrigeration	CO_2 as a refrigerant	Faster cooling rates, and eliminates need for compressor systems	Varies

A California study[48] of industrial markets had nearly identical process improvements identified as those identified in the NYS manufacturing fact sheets. That study observed systems both in the process machinery and equipment serving the facility itself with wide ranging ages and efficiencies that presented large pockets of efficiency opportunities. Many systems were also observed to be overseen by different vendors with opportunities for integrated operations. Finally, the California study identified more detailed refrigeration optimization opportunities, including head pressure adjustments, adjustment of suction pressure, sequencing of refrigeration compressors, temperature adjustments, improving insulation, adding VFDs to compressors, and installation of new, more energy efficient compressors.

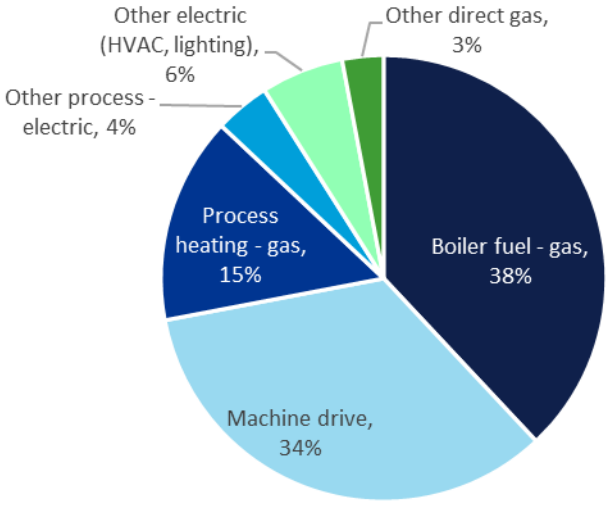
Pulp and Paper (NAICS 322)

The processes used to produce paper from pulp tend to be highly thermal-energy intensive. A 2015 DOE bandwidth study of the industry (Miller, 2015) highlights the two most energy-intensive processes within paper production: paper drying and machine wet end. Additionally, from the New York State Manufacturing Fact Sheet on Pulp and Paper: "According to the 2014 Manufacturing Energy Consumption Survey (MECS), papermaking in the Northeast census region consumes over 214 trillion Btus of energy per year, accounting for over 16% of all the energy consumed in manufacturing across the region."

Paper drying and the machine wet end, or the stock preparation ahead of the paper machine, are two of the most energy-intensive processes in these plants. However, they are not the only energy users in the process. Figure 4-5 shows a breakdown of the energy use in a typical papermaking plant.

[48] CPUC Industrial/Agricultural Market Saturation Study; 2021 Potential and Goals Study, DNV GL and Guidehouse, February 9, 2021.

Figure 4-5. Energy distribution in papermaking (NAICS 322)



A summary of energy efficiency opportunities from the New York State Manufacturing Fact Sheets can be seen in Table 4-8. Given the high consumption rate of boiler and process heat shown above, there are several attendant opportunities for energy savings associated with them.

Table 4-8. Energy improvement opportunities, Pulp and Paper[49] (NAICS 322)

Process Step	Target Action	Purpose	Energy Savings
Overall energy management system (EMS)	Energy monitoring and control systems	Monitor and control energy systems	8%
Boiler system	Boiler shell insulation improvement and heater circuit controls	Minimize shell loss while maintaining output temperature range	6%-26%
Steam distribution systems	Improved insulation	Reduce heat loss throughout the distribution system	4%-13%
	Leak repair	Reduce heat losses through the system	2%
	Steam trap maintenance & improvement	Replace malfunctioning steam traps and implement automated monitoring to minimize losses	10%-15%
Pump systems	Adjustable speed drives	Drives throttle pumps to better match speed to load requirements	20%-50%
	High-efficiency pumps	Newer pumps and pump upgrades increase drive efficiency	2%-10%
Compressed air systems	Maintenance and improvements	Evaluates current system for sizing, equipment age, etc.	Varies based on system

[49] Improving Industrial Efficiency: Paper Manufacturing, NYSERDA Fact Sheet

Process Step	Target Action	Purpose	Energy Savings
	Leak reduction	Reduction in leaks reduces pressure loss, which reduces energy used by the compressor	10%-15%
	Heat recovery	Recover heat produced in the process and use of compressed air	20%
Process-specific systems	Waste heat recovery	Recover waste heat produced in the various steps of the papermaking process, such as recycling superheated steam into the drying process, recovering ventilation air from drying and using it for space heat, or recovering hood exhaust air to preheat the air entering the combustion chamber.	Up to 50%

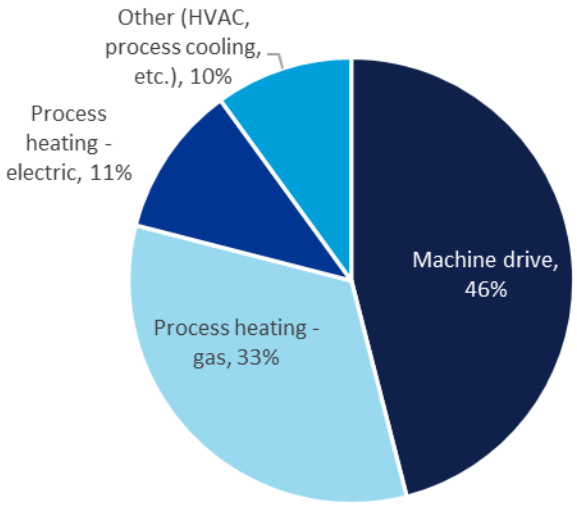
Nonmetallic Minerals (NAICS 327)

This sector covers a variety of materials, including cement, bricks, glass, ceramics, and mineral wool. Cement and concrete use the most energy in the sector; however, each of these areas have similar process steps involved. The key thermal and electric-intensive sub-processes involved in cement and concrete production are:

1. Kiln feed prep
2. Pyroprocessing with cooling
3. Finish grinding

The electric-intensive processes rely heavily on grinding, accounting for machine drive energy use in the subsector, while the pyroprocessing and cooling processes require gas-proved thermal energy. A breakdown of the energy use in cement and concrete manufacturing can be seen in Figure 4-6.

Figure 4-6. Energy distribution in cement and concrete manufacturing (NAICS 327)



A summary of cross-cutting widely applicable energy efficiency opportunities in non-metallic mineral manufacturing from the New York State Manufacturing Fact Sheets can be seen in Table 4-9.

Table 4-9. Energy improvement opportunities, Nonmetallic Minerals – Cross-cutting[50] (NAICS 327)

Process Step	Target Action	Purpose	Energy Savings
Preventive maintenance	Implement preventive maintenance programs across all plant systems	Increase plant utilization ratio by reducing downtime	3 kWh/ton clinker
Motor systems	Adjustable speed drives (ASDs)	Better match motor/pump speed to the application	5-7 kWh/ton cement
	High-efficiency motors	Replace equipment with higher efficiency units	5 kWh/ton cement
	High-efficiency fans	Replace equipment with higher efficiency units	1 kWh/ton clinker
Boiler system	Boiler shell insulation improvement and heater circuit controls	Minimize shell loss while maintaining output temperature range	6%-26% (combined)
	Boiler economizers	Use flue gases to preheat boiler feedwater	5%-10%

A summary of process-specific energy efficiency opportunities in non-metallic mineral manufacturing from the New York State Manufacturing Fact Sheets can be seen in Table 4-10.

Table 4-10. Energy improvement opportunities, Nonmetallic Minerals – Energy-specific (NAICS 327)[51]

Process Step	Target Action	Purpose	Energy Savings
Raw materials prep (wet or dry process specified where applicable)	Efficient transport systems	Convert pneumatic transport systems to mechanical systems—more efficient, increases reliability, and reduces downtime	1.9 kWh/ton raw material
	Conversion to closed circuit classifier wash mill (wet)	Replacing a tube mill with a wash mill reduces electricity consumption required for raw grinding	5-7 kWh/ton raw material
	Advanced raw meal grinding (dry)	Replacing traditional ball mills with roller mills reduces the electricity used to grind raw materials	6-7 kWh/ton raw material

[50] Improving Industrial Efficiency: Nonmetallic Mineral Production (Updated), NYSERDA Fact Sheet

[51] Ibid.

Process Step	Target Action	Purpose	Energy Savings
	High-efficiency classifiers/separators	High-efficiency classifier/separators keep material inside them longer with improved air distribution for a more uniform cut while using less electricity	2.5-3.4 kWh/ton raw material
Kiln fuel prep	Fuel prep mills	Replacement of impact or tube mills for fuel prep with energy-efficient vertical roller mills reduces energy use with increased fuel prep capacity and variety	14-21 kWh/ton fuel prepared
Clinker production (dry)	Low-pressure drop cyclones for suspension pre-heaters	Reducing pressure also reduces overall pressure losses, lowering energy consumption	3 kWh/ton clinker
	Heat recovery for power generation	Recycling waste heat of various processes (kiln exit gases, cooler system, preheating system) for use in cogeneration equipment	Savings up to 10% for primary energy, 30% electric, or 20 kWh/ton clinker
	Long dry kiln conversion	Conversion of a long dry kiln to a multi-stage pre-heater reduces heat losses	1.2-1.4 kBtu/ton clinker
Clinker production (wet and dry)	Energy management and process control	Automation of systems involved in the kiln combustion process reduces energy waste	3-8% energy savings
	Kiln combustion system improvements	Optimization of the flame shape, fuel and air mixture, and reducing excess air produce fuel savings	2-10% fuel savings
	Indirect kiln firing	Indirect firing optimizes flame and combustion conditions, reducing fuel requirements for the kiln	130-190 kBtu/ton of clinker
	Heat loss reduction	Insulation of the kiln and preheater shells reduces heat loss and increases efficiency	17 kBtu/ton clinker
	Refractories	Protecting the steel kiln shell against heat, chemical, & mechanical stress allows longer operating periods & fewer downtimes	54 kBtu/ton clinker
	Efficient clinker cooler technologies	Modern efficient clinker cooler technologies have higher heat recovery, generating higher energy savings	Up to 8% fuel savings
	Energy management and process control	Flow controls and real-time measurement of particle size reduce the grinding electricity use	3-8% energy savings
	High-efficiency classifiers/separators	Reduce electric consumption in the grinding mill.	5-7 kWh/ton cement
Finish grinding	Addition of a pre-grinding system to a ball mill	Pre-grinding helps to reduce mill runtime	6-20 kWh/ton cement

Process Step	Target Action	Purpose	Energy Savings
	Replacing ball mills with high efficiency roller mills	Roller mills have lower runtimes and are more efficient than ball mills	11-25 kWh/ton cement
	Improved grinding media	Using more durable materials in ball mills (i.e., chromium steel) and improving grinding media design requires the ball mills to run more efficiently	1.8 kWh/ton cement

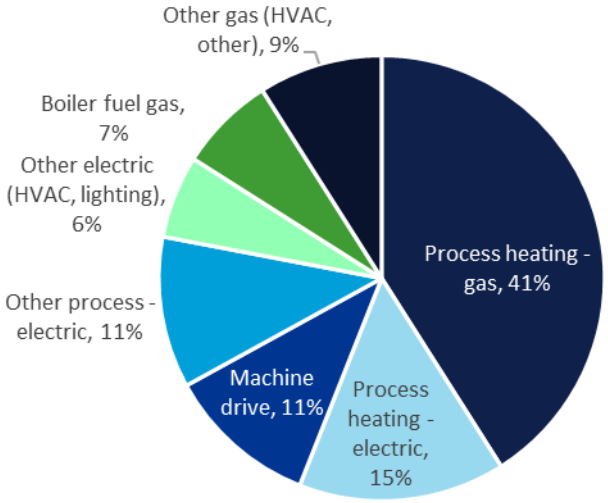
Primary Metals Manufacturing (NAICS 331)

Primary metals manufacturing includes iron and steel mills and ferroalloy manufacturing, steel product manufacturing from purchased steel, alumina and aluminum production and processing, nonferrous metal production and processing and foundries. The primary process steps in this category include heating and grinding of the raw material to create the finished product. Iron and steel mills use the most electric energy with non-ferrous metals being the next largest. The most energy-intensive processes for iron and steel manufacturing are:

- **Use of an electric arc furnace (EAF)** – Requires 401 kWh/ton of finished product. This category includes the furnace where metals are melted to produce material for semi-finished products.
- **Use of a hot strip mill –** Requires 121 kWh/ton of finished product. This category includes the mills that create semi-finished steel products such as slabs.

A breakdown of approximate energy use by end use in primary metal plants can be seen in Figure 4-7.

Figure 4-7. Energy distribution in primary metals (NAICS 331)



A summary of cross-cutting widely applicable energy efficiency opportunities in primary metal manufacturing from the New York State Manufacturing Fact Sheets can be seen in Table 4-11.

Table 4-11. Energy improvement opportunities, Primary Metals manufacturing – Cross-cutting[52] (NAICS 331)

Process Step	Target Action	Purpose	Energy Savings
Process control systems	Energy monitoring and control systems	Monitor and control process systems	Up to 20%
Boiler system	Boiler shell insulation improvement and heater circuit controls	Minimize shell loss while maintaining output temperature range	6%-26% (combined)
	Boiler economizers	Use flue gases to preheat boiler feedwater	5%-10%
Motor and pump systems	Variable speed drives	Drives throttle pumps to better match speed to load requirements	20%-50%
	High-efficiency motors and pumps	Newer pumps and pump upgrades increase drive efficiency	2%-10%
Compressed air systems	Maintenance and improvements	Evaluates current system for sizing, equipment age, etc.	Varies based on system
	Leak reduction	Reduction in leaks reduces pressure loss, which reduces energy used by the compressor	10%-15%
	Heat recovery	Recover heat produced in the process and use of compressed air	20%

A summary of process-specific energy efficiency opportunities in primary mineral manufacturing from the New York State Manufacturing Fact Sheets can be seen in Table 4-12.

Table 4-12. Energy improvement opportunities, Primary Metals manufacturing – Energy-specific (NAICS 331)[53]

Process Step	Target Action	Purpose	Energy Savings
Blast oxygen furnace (BOF)	Variable speed drive on ventilation fans	BOF has varying operation-dependent requirements for gas removal. Installation of VSDs on the BOF exhaust fans allow fan speed to dynamically match those gas requirements during operation, increasing efficiency	Up to 50%
Electric arc furnace (EAF)	Adjustable speed drives on dust collection fans	Dust-collection fans operate in a more energy efficient manner, throttling fan speed to match load requirements	67%

[52] Improving Industrial Efficiency: Primary Metal Manufacturing (Updated), NYSERDA Fact Sheet

[53] Ibid.

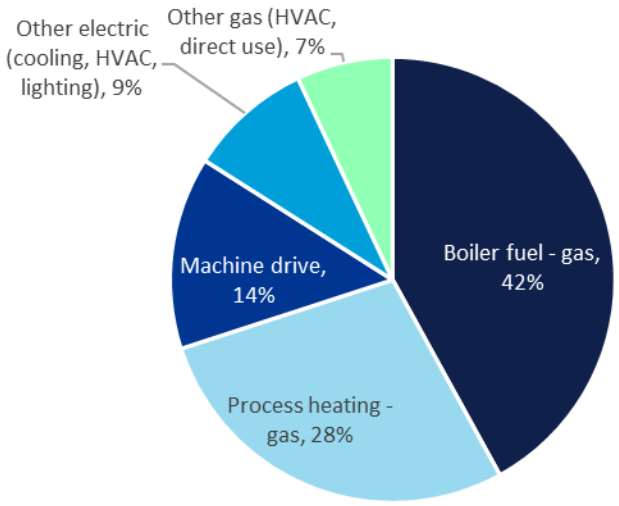
Process Step	Target Action	Purpose	Energy Savings
	Improve process control	Using a multitude of sensors, process variables (such as bath temp., carbon levels, etc.) can be monitored in real-time, allowing them to be adjusted for higher efficiency operation	2%-4% (electric) 8%-16% (gas)
	Install direct current arc furnaces	Using a single electrode to create heat and magnetic force to melt the metals generates energy savings and higher melting efficiencies	5%
Casting and refining	Integration of casting and rolling	Rolling the casted slab directly in the hot strip mill as opposed to separately	35%-43%
	Ladle preheating	Installation of temperature controls and other measures to assist in ladle preheat reducing energy required to heat the ladle	26%-28%
Hot rolling	Install recuperative or regenerative burners	Recuperative burners use gas-to-gas heat exchangers on the stack of the furnace to recover heat by preheating the combustion air	10%-20% (Recup.)
		Regenerative burners use process exhaust gases to heat a storage medium which, when full, shuts off the exhaust flow and discharges, preheating the cold combustion air	Up to 35% (Regen.)
	Insulate reheat furnaces	Insulation lowers heat losses through the walls of the furnace when in operation	2%-5%
	Proper reheating temperature	Lowering the reheat temperature using a systems approach can balance a reduction in unit fuel consumption without an increase in load on the machine drive systems	9%-10%
	Recover heat to the product	In cases where slabs cannot be hot-charged from the caster, heat can be redirected from the exhaust gases in the high-temperature portion of the process	50%

Chemical Manufacturing (NAICS 325)

Chemical manufacturing transforms organic or inorganic raw materials by a chemical process to create a product. In NYS, this can include products such as fertilizers, petrochemicals, plastics, rubber, and

pharmaceuticals. These chemical processes have more variation than some of the other manufacturing sub-sectors. The most electricity-consuming equipment in this sector is boilers for process and machine drives for electric. Figure 4-8 was derived from a 2014 Manufacturing Energy Consumption Survey (MECS).

Figure 4-8. Energy distribution in chemical manufacturing (NAICS 325)



A summary of cross-cutting widely applicable energy efficiency opportunities in chemical manufacturing from the New York State Manufacturing Fact Sheets can be seen in Table 4-13.

Table 4-13. Energy improvement opportunities, Chemical manufacturing – Cross-cutting[54] (NAICS 325)

Process Step	Target Action	Purpose	Energy Savings
Boiler system	Improved boiler maintenance	Simple maintenance to ensure all components are operating at peak performance	10%
	Boiler shell insulation improvement and heater circuit controls	Minimize shell loss while maintaining output temperature range	6%-26% (combined)
	Boiler economizers	Use flue gases to preheat boiler feedwater	5%-10%
Furnaces/ process heaters	Heat recovery	Use of flue gases to pre-heat combustion air	8%-18% fuel savings
	Improved controls	Improved controls managing the air-to-fuel ratio ensure complete combustion and minimize losses.	2%-25%
	High efficiency motors and pumps	Newer motors and pumps or upgrades increase drive efficiency	2%-10%

[54] Improving Industrial Efficiency: Chemical Manufacturing (Updated), NYSERDA Fact Sheet

Process Step	Target Action	Purpose	Energy Savings
General motor systems	Variable speed drives	Drives throttle pumps to better match speed to load requirements	20%-50%
	System maintenance	Proper maintenance increases system efficiency and longevity	2%-30%

A summary of process-specific energy efficiency opportunities in chemical manufacturing from the New York State Manufacturing Fact Sheets can be seen in Table 4-14.

Table 4-14. Energy improvement opportunities, Chemical manufacturing – Process energy-specific (NAICS 325)[55]

Process Step	Target Action	Purpose	Energy Savings
Steam systems	Reduce steam pressure	Steam pressure can be reduced to only what is needed without affecting plant production, using less boiler fuel	Varies by plant and product
Cogeneration	Addition of a combined heat and power (CHP) cogeneration system	Cogeneration uses process and excess heat to produce electricity for use in the plant, saving energy	Varies by plant size
Furnaces/process heaters	Improved heat transfer	Improving heat transfer of boiler tubing and material	4%-12%
	Improved process controls	Process controls improving material handling, heat storage, turndown, etc. reducing losses	2%-10%
	Process integration	Use total site pinch analysis to identify and exploit potential synergies between systems, linking them in a thermodynamically optimal way to increase energy efficiency	10%-15% total energy savings from economically feasible options
Compressed air systems	Plant-wide system assessment	Conduct a plant-wide compressed air system assessment to identify process-specific ECMs	18%
Distillation	Distillation process optimization	Optimization of the distillation process through controls, pressure adjustments, equipment insulation, etc.	Potential energy savings vary based on product requirements
	Product purity adjustment	Adjusting product purity levels that are higher than product requirements	

Missing a process step above?

[55] Ibid.

A California study in 2021[56] provided a great deal of detail on opportunities for advanced automation and optimization in the chemical industrial subsector. This opportunity was identified as one of the top three promising technologies based on interviews and a literature review. A brief description of the technology and target action is summarized in Table 4-15.

Table 4-15. Chemical manufacturing advanced automation and optimization

Industry System	Description and Target Action
Plant-wide monitoring and automated control systems	• Many facilities have Supervisory Control and Data Acquisition (SCADA) systems that enable real-time or interval process monitoring. However, existing systems are typically focused on discrete systems or processes in a plant, and they require manual optimization of systems or processes. • Recent advancements in machine learning allow for SCADA systems that automatically identify drifting parameters and adjust them back to desired ranges. These automated monitoring and controls systems can quickly adjust parameters for many systems and processes to optimize plant-wide operations across a variety of loads.
Variable flow primary loop systems for cooling:	In a variable flow primary pumping system, the condenser, chiller, and chilled water loop all work together to maximize efficiency and performance via automated monitoring and control of variable speed drives through the system. For example, the chiller varies its cooling capacity to maintain a desired chiller leaving water temperature, which saves compressor energy at part load conditions.
Fuel to air controls for combustion systems	Combustion systems are often not sufficiently optimized for excess air and many operate at unnecessarily low combustion efficiencies. These systems are typically manually tested and optimized annually. Most existing systems use constant speed drives and require manual optimization of excess air. Newer systems use variable speed drives and advanced controls to automate optimization.

[56] CPUC Industrial/Agricultural Market Saturation Study; 2021 Potential and Goals Study, DNV GL and Guidehouse, February 9, 2021.

Appendix F: Manufactured Products by NAICS

This appendix contains tables of the top ten manufactured products for each manufacturing NAICS code as determined by sales dollars from MECS.

National 315 Apparel top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Clothing, costumes, vestments, and fur apparel	54.1%
Apparel manufacturing services	26.4%
Wholesaling services for clothing	6.0%
Clothing accessories and personal accessories, except shoes, handbags, and jewelry	5.7%
Miscellaneous products for textile manufacturing	4.3%
Wholesaling services for clothing accessories, including costume jewelry	1.9%
NA	0.5%
Handling and packing and related services for goods	0.2%
Printing and related manufacturing services	0.2%
Embroideries	0.2%
Other	0.5%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 312 Beverage and Tobacco Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Soft drinks, bottled water, and ice	27.7%
Cigarettes, including nontobacco	25.2%
Alcoholic beverages, except beer	19.6%
Beer, ale, and malt beverages	16.7%
Other tobacco products and smoking accessories	4.3%
Alcoholic beverages, prepared and served or dispensed for immediate consumption	1.4%
Materials and supplies for tobacco manufacturing	1.2%
Meals, snacks, other food items, and nonalcoholic beverages, prepared and served or dispensed for immediate consumption	0.8%
NA	0.8%
Wholesaling services for alcoholic beverages	0.7%
Other	1.5%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 325 Chemicals top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Plastics and resin products	18.6%
Pharmaceutical preparations, including prescribed and nonprescribed drugs and medicines	16.5%
Gum and wood chemicals, cyclic intermediates, and all other basic organic chemicals	10.2%
Petrochemicals	8.7%
Biological products	6.3%
Fuel ethanol (fuel-grade alcohol) and other biofuels	5.1%
Paint, coating, sealant, and other related products	4.2%
All other basic inorganic chemicals	3.9%
Fertilizer, soil improvement, and pesticide products	2.6%
Cosmetics, creams, lotions, oils, and other toilet preparations	1.9%
Other	22.0%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 334 Computer and Electronic Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Semiconductors and other electronic components	27.7%
Computers and peripheral equipment and communications equipment	17.7%
Navigational, measuring, and control instruments, nec.	16.5%
Electromedical and irradiation equipment	14.4%
Materials and supplies for computers and office machinery	9.2%
Electronic and electrical manufacturing services	3.4%
Electrical, communication, and lighting system products	2.5%
Materials and supplies for maintenance and repair of commercial and service industry machinery and equipment, except cooking and food-warming	2.1%
Totalizing fluid meter and counting devices	1.1%
Hearing aids	1.1%
Other	4.2%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 335 Electrical Equip., Appliances, and Components top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Electrical, communication, and lighting system products	29.9%
Household appliances	14.7%
Relays, industrial controls, and laser system products	12.6%
Electricity control and distribution equipment	9.6%
Ignition, electrical, and electronic products	4.4%
Ferroalloys and miscellaneous materials and supplies for primary metals manufacturing	3.5%
Electricity generation equipment	3.1%
Wholesaling services for electrical, communication, and lighting system products	2.8%
Storage batteries	2.5%
Other building system products, nec.	2.4%
Other	14.5%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 311 Food top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Other processed meat	8.9%
Beef and veal, fresh and frozen cuts	6.3%
Poultry and fowl	6.3%
Cheese, including cottage cheese	6.0%
Breads, cakes, pies, pastries, and tortillas	5.5%
Snack foods, except cakes and pastries, frozen goods, and dried fruits	5.0%
Flour and other milled grain and oilseed products, except oils and products for animal feed	5.0%
Other food products	3.4%
Fluid milk	3.1%
Processed poultry	3.1%
Other	47.6%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 337 Furniture and Related Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Wood kitchen and bathroom cabinet and counter products	20.5%
Home furniture	18.0%
Commercial and institutional furniture	12.9%
All other miscellaneous materials and supplies for construction and mining	11.8%
Mattresses, including wire spring, innerspring, and other mattresses	11.7%
Office furniture, except wood	11.0%
Wood office furniture	3.8%
Window treatments	3.4%
Lumber and wood, except for construction	1.3%
Furniture and related product manufacturing services	0.9%
Other	4.7%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 316 Leather and Allied Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Footwear and shoe accessories	34.6%
Leather, hides, and skins, finished and unfinished	32.0%
Luggage, including suitcases, travel bags, backpacks, and other types	9.8%
Other household and personal goods, nec.	4.6%
Miscellaneous materials and supplies for services, nec.	4.0%
Supplies and accessories for household pets	2.5%
Apparel manufacturing services	2.4%
Miscellaneous products for textile manufacturing	2.2%
Wholesaling services for footwear and footwear accessories	2.1%
Wholesaling services for disposable paper and plastic products and other materials and supplies for service industries, nec.	1.5%
Other	4.3%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 333 Machinery top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Construction, forestry, mining, and oil and gas field machinery and equipment	13.5%
Plumbing, heating, and air-conditioning system products and commercial kitchen sheet metal products	7.9%
Engine and propulsion unit products, except for aircraft	6.6%
Tractors and other agricultural machinery and equipment	5.1%
Pumps and compressors	4.5%
Other special industry machinery and equipment, nec.	4.5%
Commercial and service industry equipment, nec.	4.4%
Other materials handling equipment	4.2%
All other miscellaneous general industrial machinery	3.6%
Industrial molds, dies, and patterns	3.5%
Other	42.2%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 339 Miscellaneous top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Surgical and medical instruments	19.7%
Electric and nonelectric signs and displays	8.9%
Surgical and medical appliances and supplies	7.0%
Orthopedic and prosthetic appliances, other types, except intraocular lenses	6.0%
Sporting goods and equipment	5.1%
Gasket, packing, and sealing device products; rubber mechanical goods	4.7%
Dental products	4.6%
Watches, fine jewelry, and costume jewelry	4.5%
Commercial and service industry equipment, nec.	4.2%
Wholesaling services for industrial, commercial, and service industry machinery and equipment	4.0%
Other	31.2%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 327 Nonmetallic Mineral Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Materials and supplies for masonry construction, nec.	28.2%
Structural metal, brick, block, and dimension stone, and structural wood used for construction	17.7%
Portland cement and other Portland hydraulic cements (including oil well, white cement, blended cements, etc.), and masonry cement and cement clinker	7.1%
Window and door products	6.8%
Interior wall-forming products, including partitions	5.0%
Bottles, jars, cans, and closures	4.2%
All other miscellaneous materials and supplies, nec.	4.1%
Roofing, siding, and insulation products	3.2%
Motor vehicle body and attachment products	2.3%
Flat glass (float, sheet, and plate process)	2.2%
Other	19.2%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 324 Petroleum and Coal Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Refined petroleum fuels, except biofuels	77.8%
Petrochemicals	4.0%
Lubricant and grease products	3.9%
Miscellaneous products for petroleum and coal products manufacturing	3.9%
Wholesaling services for fuels for heat, power, and transportation	3.3%
Materials and supplies for paving construction	2.4%
Gum and wood chemicals, cyclic intermediates, and all other basic organic chemicals	1.9%
Roofing, siding, and insulation products	1.7%
Coke oven and blast furnace products, except slag	0.4%
Other fuels	0.2%
Other	0.5%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 326 Plastics and Rubber Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Bottles, jars, cans, and closures	10.9%
Unlaminated plastics film, sheet, and shapes, except for packaging	10.4%
Fabricated plastics products for transportation equipment	9.9%
Tires and tire replacement and repair products	8.4%
Plumbing, heating, and air-conditioning system products and commercial kitchen sheet metal products	5.9%
Flexible packaging roll and sheet products	5.9%
Miscellaneous materials and supplies for services, nec.	5.1%
Bag, pouch, and liner products	4.9%
Roofing, siding, and insulation products	3.5%
NA	2.9%
Other	32.2%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 331 Primary Metals top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Iron and steel in primary and mill shapes, except pipe and tube	34.4%
Primary, secondary, and alloyed aluminum in primary and mill shapes, except pipe and tube	12.5%
Metal castings	12.2%
Other primary, secondary, and alloyed nonferrous metals in primary and mill shapes, except wire, pipe, and tube	9.4%
Primary, secondary, and alloyed copper in primary and mill shapes, except pipe and tube	6.8%
Structural metal, brick, block, and dimension stone, and structural wood used for construction	6.5%
Nonferrous wire, cord, and cable products	5.1%
Metal pipe and tube, except copper plumbing pipe and cast iron pipe	3.7%
Ferroalloys and miscellaneous materials and supplies for primary metals manufacturing	3.7%
Coke oven and blast furnace products, except slag	1.0%
Other	4.6%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 323 Printing and Related Support top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Printing and related manufacturing services	91.3%
Office and school supplies, except paper	1.4%
NA	1.3%
Paper office and school supplies	1.1%
Electric and nonelectric signs and displays	0.7%
Handling and packing and related services for goods	0.6%
Embroideries	0.6%
Wholesaling services for clothing	0.5%
Nonelectronic games and puzzles, including parts	0.4%
Unlaminated plastics film, sheet, and shapes, except for packaging	0.4%
Other	1.7%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 313 Textile Mills top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Yarns	27.6%
Broadwoven fabrics, gray goods and finished	23.4%
All other miscellaneous materials and supplies, nec.	13.4%
Textile manufacturing services	10.4%
Knit fabrics	7.8%
Miscellaneous products for textile manufacturing	5.8%
Narrow fabrics	4.2%
Wholesaling services for materials and supplies for clothing, leather, and footwear manufacturing	1.5%
Threads	1.1%
Other household textile products, except floor coverings and window treatments	1.1%
Bed linens	3.7%
Other	27.6%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 314 Textile Product Mills top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Flooring, floor coverings, wall tiles, and wallpaper	17.9%
Other household textile products, except floor coverings and window treatments	10.2%
All other miscellaneous materials and supplies	8.9%
Bed linens	7.8%
Window treatments	7.6%
Rubber products	6.9%
Textile manufacturing services	6.6%
Rope, cordage, and twine products	5.5%
Other household furnishings	5.2%
Miscellaneous parts and components for motor vehicle, rail, and other transportation equipment	4.3%
Other	19.1%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 336 Transportation Equipment top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Automobiles and light-duty trucks	38.5%
Aircraft	11.8%
Buses, heavy-duty trucks, and heavy-duty trailers, including chassis	5.0%
Miscellaneous materials and supplies for aerospace manufacturing, except hardware	4.9%
Metal stampings for machinery, transportation, and other equipment manufacturing	4.5%
Power train products	2.8%
Miscellaneous parts and components for motor vehicle, rail, and other transportation equipment	2.7%
Transportation equipment manufacturing services	2.7%
Aircraft engines and parts and accessories	2.6%
Transportation seating products	2.4%
Other	22.2%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

National 321 Wood Products top 10 manufactured products

Manufactured Product	% of total 3-digit NAICS dollar shipments
Structural metal, brick, block, and dimension stone, and structural wood used for construction	28.3%
Lumber and wood, except for construction	21.6%
Window and door products	14.8%
Pallets	8.8%
NA	5.0%
Prefabricated buildings and components	3.8%
Miscellaneous materials and supplies for services, nec.	3.6%
Constructions of residential buildings, except apartment buildings	3.6%
Wood product manufacturing services	2.7%
Flooring, floor coverings, wall tiles, and wallpaper	2.0%
Other	5.8%

Calculated using 2017 Economic census tables EC1700NAPCSINDPRD, EC1700NAPCSPRDIND, and 2017 NAPCS Trilateral Product Code to NAPCS-Based Collection Code

Appendix G: End Use Consumption by Fuel, Tier, and Manufacturing NAICS

This appendix provides a series of tables showing energy consumption by fuel, and Tier for each manufacturing NAICS. All tables in this section are imputed for New York state, calculated using 2018 MECS Table 3.2, Table 6.1, Table 5.2, and Data Axle. The following manufacturing subsectors were not able to have any values imputed in this section:

- Furniture and Related Products (337)
- Textile Mills (313)
- Textile Product Mills (313)

315 Apparel

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	a	a	99,091	a	a	a	a	a	a	22,432	0	76,659
Conventional Boiler Use	a	a	a	a	a	a	a	a	a	a	a	a
CHP and/or Cogeneration Process	0	a	a	0	0	0	a	a	a	a	a	a
Process Heating	a	a	a	a	a	a	a	a	a	a	a	a
Process Cooling and Refrigeration	a	a	a	a	a	a	a	a	a	a	a	a
Machine Drive	49,546	a	a	11,216	0	38,330	a	a	a	a	a	a
Electro-Chemical Processes	a	a	a	a	a	a	a	a	a	a	a	a
Other Process Use	a	0	a	a	a	a	0	0	0	a	a	a
Facility HVAC	49,546	a	a	11,216	0	38,330	a	a	a	a	a	a
Facility Lighting	a	a	a	a	a	a	a	a	a	a	a	a
Other Facility Support	a	a	a	a	a	a	a	a	a	a	a	a
Onsite Transportation	a	0	a	a	a	a	0	0	0	a	a	a
Conventional Electricity Generation	a	0	a	a	a	a	0	0	0	a	a	a
Other Nonprocess Use	a	a	a	a	a	a	a	a	a	a	a	a
End Use Not Reported	a	a	a	a	a	a	a	a	a	a	a	a
Total	99,091	0	99,091	22,432	0	76,659	0	0	0	22,432	0	76,659

a Denotes instances where there was not enough information to impute a value.

312 Beverage and Tobacco Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	a	a	623,261	a	a	a	a	a	a	268,164	78,792	76,305
Conventional Boiler Use	36,662	659,923	a	15,774	4,635	16,253	283,939	83,427	292,558	a	a	a
CHP and/or Cogeneration Process	0	623,261	a	0	0	0	268,164	78,792	276,305	a	a	a
Process Heating	36,662	439,949	a	15,774	4,635	16,253	189,293	55,618	195,039	a	a	a
Process Cooling and Refrigeration	329,962		a	141,969	41,713	146,279	a	a	a	a	a	a
Machine Drive	879,898	36,662	a	378,585	111,236	390,077	15,774	4,635	16,253	a	a	a
Electro-Chemical Processes	a	a	a	a	a	a	a	a	a	a	a	a
Other Process Use	36,662	36,662	a	15,774	4,635	16,253	15,774	4,635	16,253	a	a	a
Facility HVAC	183,312	146,650	a	78,872	23,174	81,266	63,098	18,539	65,013	a	a	a
Facility Lighting	146,650	a	a	63,098	18,539	65,013	a	a	a	a	a	a
Other Facility Support	36,662	36,662	a	15,774	4,635	16,253	15,774	4,635	16,253	a	a	a
Onsite Transportation	36,662	a	a	15,774	4,635	16,253	a	a	a	a	a	a
Conventional Electricity Generation	a	a	a	a	a	a	a	a	a	a	a	a
Other Nonprocess Use	a	a	a	a	a	a	a	a	a	a	a	a
End Use Not Reported	a	a	a	a	a	a	a	a	a	a	a	a
Total	1,723,133	1,979,770	623,261	741,396	217,836	763,901	851,817	250,280	877,673	268,164	78,792	76,305

a Denotes instances where there was not enough information to impute a value.

325 Chemicals

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	4,766,268	[a]	[a]	[a]	[a]	[a]	[a]	3,128,793	651,319	986,156
Conventional Boiler Use	29,543	1,915,370	[a]	19,393	4,037	6,113	1,257,335	261,739	396,296	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	4,003,074	[a]	0	0	0	2,627,798	547,027	828,249	[a]	[a]	[a]
Process Heating	93,553	3,924,293	[a]	61,412	12,784	19,356	2,576,082	536,262	811,949	[a]	[a]	[a]
Process Cooling and Refrigeration	226,496	44,314	[a]	148,682	30,951	46,863	29,090	6,056	9,169	[a]	[a]	[a]
Machine Drive	1,403,292	438,221	[a]	921,184	191,762	290,345	287,668	59,884	90,669	[a]	[a]	[a]
Electro-Chemical Processes	300,354	[a]	[a]	197,166	41,044	62,144	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	54,162	787,813	[a]	35,554	7,401	11,206	517,156	107,656	163,001	[a]	[a]	[a]
Facility HVAC	162,486	280,658	[a]	106,663	22,204	33,619	184,237	38,352	58,069	[a]	[a]	[a]
Facility Lighting	93,553		[a]	61,412	12,784	19,356	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	34,467	54,162	[a]	22,626	4,710	7,131	35,554	7,401	11,206	[a]	[a]	[a]
Onsite Transportation	4,924	[a]	[a]	3,232	673	1,019	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	4,924	[a]	[a]	[a]	[a]	3,232	673	1,019	[a]	[a]	[a]
Other Nonprocess Use	9,848	14,771	[a]	6,464	1,346	2,038	9,697	2,019	3,056	[a]	[a]	[a]
End Use Not Reported	49,238	78,781	[a]	32,322	6,729	10,188	51,716	10,766	16,300	[a]	[a]	[a]
Total	2,461,915	11,546,382	4,766,268	1,616,112	336,425	509,378	7,579,565	1,577,834	2,388,983	3,128,793	651,319	986,156

a Denotes instances where there was not enough information to impute a value.

334 Computer and Electronic Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	76,887	[a]	[a]	[a]	[a]	[a]	[a]	42,960	9,899	24,028
Conventional Boiler Use	38,444	307,549	[a]	21,480	4,949	12,014	171,840	39,595	96,114	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	115,331	[a]	0	0	0	64,440	14,848	36,043	[a]	[a]	[a]
Process Heating	269,105	38,444	[a]	150,360	34,645	84,100	21,480	4,949	12,014	[a]	[a]	[a]
Process Cooling and Refrigeration	461,323	[a]	[a]	257,760	59,392	144,171	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	538,210	[a]	[a]	300,720	69,291	168,199	[a]	[a]	[a]	[a]	[a]	[a]
Electro-Chemical Processes	76,887	[a]	[a]	42,960	9,899	24,028	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	269,105	38,444	[a]	150,360	34,645	84,100	21,480	4,949	12,014	[a]	[a]	[a]
Facility HVAC	730,428	576,654	[a]	408,120	94,038	228,271	322,200	74,240	180,214	[a]	[a]	[a]
Facility Lighting	230,661		[a]	128,880	29,696	72,085				[a]	[a]	[a]
Other Facility Support	115,331	38,444	[a]	64,440	14,848	36,043	21,480	4,949	12,014	[a]	[a]	[a]
Onsite Transportation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	38,444	38,444	[a]	21,480	4,949	12,014	21,480	4,949	12,014	[a]	[a]	[a]
End Use Not Reported	115,331	[a]	[a]	64,440	14,848	36,043	[a]	[a]	[a]	[a]	[a]	[a]
Total	2,883,268	1,153,307	76,887	1,610,998	371,201	901,068	644,399	148,480	360,427	42,960	9,899	24,028

a Denotes instances where there was not enough information to impute a value.

335 Electrical Equip., Appliances, and Components

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	332,425	[a]	[a]	[a]	[a]	[a]	[a]	142,034	54,702	135,688
Conventional Boiler Use	[a]	60,441	[a]	[a]	[a]	[a]	25,824	9,946	24,671	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	[a]	[a]	0	0	0	[a]	[a]	[a]	[a]	[a]	[a]
Process Heating	241,763	543,967	[a]	103,298	39,783	98,682	232,420	89,512	222,035	[a]	[a]	[a]
Process Cooling and Refrigeration	60,441	[a]	[a]	25,824	9,946	24,671	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	392,865	[a]	[a]	167,859	64,648	160,359	[a]	[a]	[a]	[a]	[a]	[a]
Electro-Chemical Processes	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	60,441		[a]	25,824	9,946	24,671	[a]	[a]	[a]	[a]	[a]	[a]
Facility HVAC	211,543	271,984	[a]	90,385	34,810	86,347	116,210	44,756	111,018	[a]	[a]	[a]
Facility Lighting	90,661	[a]	[a]	38,737	14,919	37,006	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	30,220	30,220	[a]	12,912	4,973	12,335	12,912	4,973	12,335	[a]	[a]	[a]
Onsite Transportation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
End Use Not Reported	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Total	1,087,935	906,612	332,425	464,839	179,025	444,071	387,366	149,187	370,059	142,034	54,702	135,688

a Denotes instances where there was not enough information to impute a value.

332 Fabricated Metal Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use		[a]	608,280	[a]	[a]	[a]	[a]	[a]	[a]	52,293	59,525	496,462
Conventional Boiler Use	22,529	[a]	[a]	1,937	2,205	18,387	[a]	[a]	[a]	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	247,818	[a]	0	0	0	21,305	24,251	202,262	[a]	[a]	[a]
Process Heating	450,577	1,577,021	[a]	38,735	44,092	367,750	135,574	154,323	1,287,124	[a]	[a]	[a]
Process Cooling and Refrigeration	112,644	[a]	[a]	9,684	11,023	91,937	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	1,148,973	[a]	[a]	98,775	112,435	937,762	[a]	[a]	[a]	[a]	[a]	[a]
Electro-Chemical Processes	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	45,058	[a]	[a]	3,874	4,409	36,775	[a]	[a]	[a]	[a]	[a]	[a]
Facility HVAC	382,991	698,395	[a]	32,925	37,478	312,587	60,040	68,343	570,012	[a]	[a]	[a]
Facility Lighting	292,875	[a]	[a]	25,178	28,660	239,037	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	67,587	45,058	[a]	5,810	6,614	55,162	3,874	4,409	36,775	[a]	[a]	[a]
Onsite Transportation	22,529	[a]	[a]	1,937	2,205	18,387	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	[a]	0	[a]	[a]	[a]	[a]	0	0	[a]	[a]	[a]	[a]
End Use Not Reported	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Total	2,545,763	2,568,292	608,280	218,855	249,121	2,077,786	220,792	251,326	2,096,173	52,293	59,525	496,462

a Denotes instances where there was not enough information to impute a value.

311 Food

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	1,272,022	[a]	[a]	[a]	[a]	[a]	[a]	441,149	187,577	643,296
Conventional Boiler Use	62,431	1,061,319	[a]	21,651	9,206	31,573	368,075	156,506	536,738	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	1,966,562	[a]	0	0	0	682,021	289,997	994,544	[a]	[a]	[a]
Process Heating	85,842	1,303,237	[a]	29,771	12,659	43,413	451,974	192,180	659,083	[a]	[a]	[a]
Process Cooling and Refrigeration	647,717	31,215	[a]	224,634	95,515	327,568	10,826	4,603	15,786	[a]	[a]	[a]
Machine Drive	1,014,496	109,253	[a]	351,836	149,601	513,058	37,890	16,111	55,252	[a]	[a]	[a]
Electro-Chemical Processes	15,608	[a]	[a]	5,413	2,302	7,893	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	23,411	109,253	[a]	8,119	3,452	11,840	37,890	16,111	55,252	[a]	[a]	[a]
Facility HVAC	257,526	413,602	[a]	89,312	37,976	130,238	143,441	60,991	209,170	[a]	[a]	[a]
Facility Lighting	218,507	[a]	[a]	75,780	32,222	110,505	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	46,823	179,488	[a]	16,239	6,905	23,680	62,248	26,468	90,772	[a]	[a]	[a]
Onsite Transportation	23,411	[a]	[a]	8,119	3,452	11,840	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	7,804	[a]	[a]	2,706	1,151	3,947	[a]	[a]	[a]	[a]	[a]	[a]
End Use Not Reported	39,019	39,019	[a]	13,532	5,754	19,733	13,532	5,754	19,733	[a]	[a]	[a]
Total	2,442,594	5,212,949	1,272,022	847,113	360,194	1,235,287	1,807,897	768,721	2,636,331	441,149	187,577	643,296

a Denotes instances where there was not enough information to impute a value.

316 Leather and Allied Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	104,414	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	104,414
Conventional Boiler Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	[a]	[a]	[a]	[a]	0	[a]	[a]	[a]	[a]	[a]	[a]
Process Heating	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Process Cooling and Refrigeration	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Electro-Chemical Processes	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Facility HVAC	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Facility Lighting	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Onsite Transportation	[a]	0	[a]	[a]	[a]	[a]	[a]	[a]	0	[a]	[a]	[a]
Conventional Electricity Generation	[a]	0	[a]	[a]	[a]	[a]	[a]	[a]	0	[a]	[a]	[a]
Other Nonprocess Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
End Use Not Reported	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Total	0	0	104,414	[a]	[a]	0	[a]	[a]	0	[a]	[a]	104,414

a Denotes instances where there was not enough information to impute a value.

333 Machinery

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	194,569	[a]	[a]	[a]	[a]	[a]	[a]	35,770	23,804	134,995
Conventional Boiler Use	12,971	[a]	[a]	2,385	1,587	9,000	[a]	[a]	[a]	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	64,856	[a]	0	0	0	11,923	7,935	44,998	[a]	[a]	[a]
Process Heating	51,885	246,454	[a]	9,539	6,348	35,999	45,308	30,152	170,993	[a]	[a]	[a]
Process Cooling and Refrigeration	38,914	[a]	[a]	7,154	4,761	26,999	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	531,821	38,914	[a]	97,770	65,065	368,986	7,154	4,761	26,999	[a]	[a]	[a]
Electro-Chemical Processes			[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	12,971	25,942	[a]	2,385	1,587	9,000	4,769	3,174	17,999	[a]	[a]	[a]
Facility HVAC	168,626	324,281	[a]	31,000	20,630	116,995	59,616	39,674	224,991	[a]	[a]	[a]
Facility Lighting	116,741		[a]	21,462	14,283	80,997	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	38,914	12,971	[a]	7,154	4,761	26,999	2,385	1,587	9,000	[a]	[a]	[a]
Onsite Transportation	12,971	[a]	[a]	2,385	1,587	9,000	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
End Use Not Reported	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Total	985,814	713,418	194,569	181,233	120,608	683,973	131,155	87,282	494,981	35,770	23,804	134,995

a Denotes instances where there was not enough information to impute a value.

339 Miscellaneous

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	853,786	[a]	[a]	[a]	[a]	[a]	[a]	142,852	94,738	616,196
Conventional Boiler Use	[a]	77,617	[a]	[a]	[a]	[a]	12,987	8,613	56,018	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	155,234	[a]	0	0	0	25,973	17,225	112,036	[a]	[a]	[a]
Process Heating	155,234	776,169	[a]	25,973	17,225	112,036	129,866	86,126	560,178	[a]	[a]	[a]
Process Cooling and Refrigeration	155,234	[a]	[a]	25,973	17,225	112,036	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	853,786	77,617	[a]	142,852	94,738	616,196	12,987	8,613	56,018	[a]	[a]	[a]
Electro-Chemical Processes	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Facility HVAC	620,935	620,935	[a]	103,892	68,900	448,142	103,892	68,900	448,142	[a]	[a]	[a]
Facility Lighting	310,468	[a]	[a]	51,946	34,450	224,071	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	77,617	[a]	[a]	12,987	8,613	56,018	[a]	[a]	[a]	[a]	[a]	[a]
Onsite Transportation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
End Use Not Reported	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Total	2,173,274	1,707,572	853,786	363,624	241,152	1,568,499	285,704	189,476	1,232,392	142,852	94,738	616,196

a Denotes instances where there was not enough information to impute a value.

327 Nonmetallic Mineral Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown	[a]	[a]	7,336,209	[a]	[a]	[a]	[a]	[a]	[a]	5,242,205	469,869	1,624,135
Conventional Boiler Use	[a]	42,162	[a]	[a]	[a]	[a]	30,128	2,700	9,334	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	210,811	[a]	0	0	0	150,638	13,502	46,671	[a]	[a]	[a]
Process Heating	548,108	5,965,940	[a]	391,659	35,105	121,343	4,263,057	382,106	1,320,777	[a]	[a]	[a]
Process Cooling and Rfg.	126,486	63,243	[a]	90,383	8,101	28,002	45,191	4,051	14,001	[a]	[a]	[a]
Machine Drive	1,496,755	527,027	[a]	1,069,530	95,864	331,361	376,595	33,755	116,676	[a]	[a]	[a]
Electro-Chem Processes	63,243	[a]	[a]	45,191	4,051	14,001	[a]	[a]	[a]	[a]	[a]	[a]
Other Process	147,567	[a]	[a]	105,447	9,451	32,669	[a]	[a]	[a]	[a]	[a]	[a]
Facility HVAC	147,567	337,297	[a]	105,447	9,451	32,669	241,021	21,603	74,673	[a]	[a]	[a]
Facility Lighting	126,486	a	[a]	90,383	8,101	28,002	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	42,162	42,162	[a]	30,128	2,700	9,334	30,128	2,700	9,334	[a]	[a]	[a]
Onsite Transportation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	21,081	21,081	[a]	15,064	1,350	4,667	15,064	1,350	4,667	[a]	[a]	[a]
End Use Not Reported	21,081	21,081	[a]	15,064	1,350	4,667	15,064	1,350	4,667	[a]	[a]	[a]
Total	2,740,538	7,230,804	7,336,209	1,958,295	175,526	606,717	5,166,886	463,118	1,600,800	5,242,205	469,869	1,624,135

a Denotes instances where there was not enough information to impute a value.

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End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown	[a]	[a]	28,709,165	[a]	[a]	[a]	[a]	[a]	[a]	22,874,100	3,306,938	2,528,127
Conventional Boiler Use	110,761	1,439,889	[a]	88,249	12,758	9,754	1,147,235	165,857	126,797	[a]	[a]	[a]
CHP and/or Cogen Process	0	7,110,835	[a]	0	0	0	5,665,576	819,080	626,180	[a]	[a]	[a]
Process Heating	110,761	3,167,755	[a]	88,249	12,758	9,754	2,523,917	364,886	278,952	[a]	[a]	[a]
Process Cooling & Rfg	110,761	[a]	[a]	88,249	12,758	9,754	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	2,946,234	155,065	[a]	2,347,419	339,369	259,445	123,548	17,862	13,655	[a]	[a]	[a]
Electro-Chem Processes	44,304	[a]	[a]	35,300	5,103	3,901	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	22,152	155,065	[a]	17,650	2,552	1,951	123,548	17,862	13,655	[a]	[a]	[a]
Facility HVAC	221,521	398,738	[a]	176,498	25,516	19,507	317,696	45,930	35,113	[a]	[a]	[a]
Facility Lighting	199,369	[a]	[a]	[a]	22,965	17,556	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	66,456	44,304	[a]	52,949	7,655	5,852	35,300	5,103	3,901	[a]	[a]	[a]
Onsite Transportation	22,152	[a]	[a]	17,650	2,552	1,951	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	132,913	[a]	[a]	[a]	[a]	105,899	15,310	11,704	[a]	[a]	[a]
Other Nonprocess Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
End Use Not Reported	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Total	3,854,471	12,604,564	28,709,165	3,071,060	443,987	339,424	10,042,718	1,451,889	1,109,957	22,874,100	3,306,938	2,528,127

a Denotes instances where there was not enough information to impute a value.

324 Petroleum and Coal Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	12,482,008	[a]	[a]	[a]	[a]	[a]	[a]	10,991,572	365,217	1,125,219
Conventional Boiler Use	5,516	739,103	[a]	4,857	161	497	650,849	21,626	66,628	[a]	[a]	[a]
CHP and/or Cogen Process	0	1,147,264	[a]	0	0	0	1,010,273	33,568	103,423	[a]	[a]	[a]
Process Heating	(11,031)	3,618,293	[a]	(9,714)	(323)	(994)	3,186,244	105,869	326,179	[a]	[a]	[a]
Process Cooling and Refrigeration	38,610	5,516	[a]	34,000	1,130	3,481	4,857	161	497	[a]	[a]	[a]
Machine Drive	865,963	82,735	[a]	762,562	25,338	78,064	72,856	2,421	7,458	[a]	[a]	[a]
Electro-Chemical Processes	5,516	[a]	[a]	4,857	161	497	a	a	a	[a]	[a]	[a]
Other Process Use	5,516	132,377	[a]	4,857	161	497	116,570	3,873	11,933	[a]	[a]	[a]
Facility HVAC	33,094	38,610	[a]	29,142	968	2,983	34,000	1,130	3,481	[a]	[a]	[a]
Facility Lighting	22,063	[a]	[a]	19,428	646	1,989				[a]	[a]	[a]
Other Facility Support	11,031	5,516	[a]	9,714	323	994	4,857	161	497	[a]	[a]	[a]
Onsite Transportation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	110,314	[a]	[a]	[a]	[a]	97,142	3,228	9,944	[a]	[a]	[a]
Other Nonprocess	[a]	5,516	[a]	[a]	[a]	[a]	4,857	161	497	[a]	[a]	[a]
End Use Not Reported	[a]	55,157	[a]	[a]	[a]	[a]	48,571	1,614	4,972	[a]	[a]	[a]
Total	976,277	5,940,399	12,482,008	859,703	28,565	88,009	5,231,075	173,813	535,511	10,991,572	365,217	1,125,219

a Denotes instances where there was not enough information to impute a value.

326 Plastics and Rubber Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	167,954	[a]	[a]	[a]	[a]	[a]	[a]	63,091	42,227	62,636
Conventional Boiler Use	[a]	142,115	[a]	[a]	[a]	[a]	53,384	35,731	53,000	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	258,391	[a]	0	0	0	97,063	64,965	96,363	[a]	[a]	[a]
Process Heating	245,471	374,666	[a]	92,209	61,717	91,545	140,741	94,199	139,726	[a]	[a]	[a]
Process Cooling and Refrigeration	180,873	[a]	[a]	67,944	45,476	67,454	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	1,111,079	[a]	[a]	417,369	279,350	414,361	[a]	[a]	[a]	[a]	[a]	[a]
Electro-Chemical Processes	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	64,598	[a]	[a]	24,266	16,241	24,091	[a]	[a]	[a]	[a]	[a]	[a]
Facility HVAC	219,632	271,310	[a]	82,503	55,220	81,909	101,916	68,213	101,181	[a]	[a]	[a]
Facility Lighting	167,954	[a]	[a]	63,091	42,227	62,636	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	64,598	12,920	[a]	24,266	16,241	24,091	4,853	3,248	4,818	[a]	[a]	[a]
Onsite Transportation	25,839	[a]	[a]	9,706	6,497	9,636	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	[a]	0	[a]	[a]	[a]	[a]	0	0	0	[a]	[a]	[a]
End Use Not Reported	[a]	0	[a]	[a]	[a]	[a]	0	0	0	[a]	[a]	[a]
Total	2,080,044	1,059,401	167,954	781,353	522,969	775,722	397,956	266,357	395,088	63,091	42,227	62,636

a Denotes instances where there was not enough information to impute a value.

331 Primary Metals

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	7,158,082	[a]	[a]	[a]	[a]	[a]	[a]	5,822,609	631,090	704,383
Conventional Boiler Use	25,474	267,473	[a]	20,721	2,246	2,507	217,571	23,582	26,320	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	598,630	[a]	0	0	0	486,944	52,778	58,907	[a]	[a]	[a]
Process Heating	1,630,310	6,113,664	[a]	1,326,146	143,736	160,429	4,973,047	539,009	601,608	[a]	[a]	[a]
Process Cooling and Refrigeration	140,105	38,210	[a]	113,966	12,352	13,787	31,082	3,369	3,760	[a]	[a]	[a]
Machine Drive	1,439,258	63,684	[a]	1,170,738	126,892	141,629	51,803	5,615	6,267	[a]	[a]	[a]
Electro-Chemical Processes	1,018,944	[a]	[a]	828,841	89,835	100,268	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	229,262	458,525	[a]	186,489	20,213	22,560	372,979	40,426	45,121	[a]	[a]	[a]
Facility HVAC	178,315	509,472	[a]	145,047	15,721	17,547	414,421	44,917	50,134	[a]	[a]	[a]
Facility Lighting	178,315		[a]	145,047	15,721	17,547	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	50,947	38,210	[a]	41,442	4,492	5,013	31,082	3,369	3,760	[a]	[a]	[a]
Onsite Transportation	12,737	[a]	[a]	10,361	1,123	1,253	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	12,737	25,474	[a]	10,361	1,123	1,253	20,721	2,246	2,507	[a]	[a]	[a]
End Use Not Reported	12,737	25,474	[a]	10,361	1,123	1,253	20,721	2,246	2,507	[a]	[a]	[a]
Total	4,929,142	8,138,815	7,158,082	4,009,519	434,576	485,046	6,620,369	717,556	800,890	5,822,609	631,090	704,383

a Denotes instances where there was not enough information to impute a value.

323 Printing and Related Support

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	154,864	[a]	[a]	[a]	[a]	[a]	[a]	15,452	15,866	123,545
Conventional Boiler Use	[a]	92,918	[a]	[a]	[a]	[a]	9,271	9,520	74,127	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	[a]	[a]	0	0	0	[a]	[a]	[a]	[a]	[a]	[a]
Process Heating	30,973	247,782	[a]	3,090	3,173	24,709	24,724	25,386	197,673	[a]	[a]	[a]
Process Cooling and Refrigeration	61,945	[a]	[a]	6,181	6,346	49,418	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	588,482	61,945	[a]	58,718	60,291	469,472	6,181	6,346	49,418	[a]	[a]	[a]
Electro-Chemical Processes	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	30,973	[a]	[a]	3,090	3,173	24,709	[a]	[a]	[a]	[a]	[a]	[a]
Facility HVAC	185,836	247,782	[a]	18,543	19,039	148,254	24,724	25,386	197,673	[a]	[a]	[a]
Facility Lighting	92,918	[a]	[a]	9,271	9,520	74,127	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	30,973	[a]	[a]	3,090	3,173	24,709	[a]	[a]	[a]	[a]	[a]	[a]
Onsite Transportation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
End Use Not Reported	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Total	1,022,100	650,427	154,864	101,985	104,716	815,399	64,899	66,638	518,890	15,452	15,866	123,545

a Denotes instances where there was not enough information to impute a value.

336 - Transportation Equipment

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	277,598	[a]	[a]	[a]	[a]	[a]	[a]	199,805	33,217	44,575
Conventional Boiler Use	15,422	215,910	[a]	11,100	1,845	2,476	155,404	25,836	34,670	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	185,065	[a]	0	0	0	133,204	22,145	29,717	[a]	[a]	[a]
Process Heating	246,754	971,593	[a]	177,605	29,527	39,622	699,319	116,261	156,013	[a]	[a]	[a]
Process Cooling and Refrigeration	169,643	30,844	[a]	122,103	20,300	27,240	22,201	3,691	4,953	[a]	[a]	[a]
Machine Drive	1,156,659	15,422	[a]	832,523	138,406	185,730	11,100	1,845	2,476	[a]	[a]	[a]
Electro-Chemical Processes	15,422	[a]	[a]	11,100	1,845	2,476	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	107,955	46,266	[a]	77,702	12,918	17,335	33,301	5,536	7,429	[a]	[a]	[a]
Facility HVAC	478,086	894,483	[a]	344,109	57,208	76,768	643,818	107,034	143,631	[a]	[a]	[a]
Facility Lighting	308,442		[a]	222,006	36,908	49,528	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	77,111	30,844	[a]	55,502	9,227	12,382	22,201	3,691	4,953	[a]	[a]	[a]
Onsite Transportation	30,844	[a]	[a]	[a]	3,691	4,953	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	15,422	15,422	[a]	11,100	1,845	2,476	11,100	1,845	2,476	[a]	[a]	[a]
End Use Not Reported	[a]	15,422	[a]	[a]	[a]	[a]	11,100	1,845	2,476	[a]	[a]	[a]
Total	2,621,759	2,421,272	277,598	1,887,052	313,721	420,987	1,742,748	289,730	388,794	199,805	33,217	44,575

a Denotes instances where there was not enough information to impute a value.

321 Wood Products

End Use	Overall (MMBtu)			Electric (MMBtu) Tier			Gas (MMBtu) Tier			Other (MMBtu) Tier		
	Electric	Gas	Other	1	2	3	1	2	3	1	2	3
Other Fuels - Unknown End Use	[a]	[a]	2,521,056	[a]	[a]	[a]	[a]	[a]	[a]	436,438	224,197	1,860,421
Conventional Boiler Use	10,044	40,176	[a]	1,739	893	7,412	6,955	3,573	29,648	[a]	[a]	[a]
CHP and/or Cogeneration Process	0	150,661	[a]	0	0	0	26,082	13,398	111,181	[a]	[a]	[a]
Process Heating	30,132	341,498	[a]	5,216	2,680	22,236	59,119	30,369	252,009	[a]	[a]	[a]
Process Cooling and Refrigeration	10,044	[a]	[a]	[a]	893	7,412	[a]	[a]	[a]	[a]	[a]	[a]
Machine Drive	532,334	20,088	[a]	92,156	47,341	392,838	3,478	1,786	14,824	[a]	[a]	[a]
Electro-Chemical Processes	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Process Use	[a]	40,176	[a]	[a]	[a]	[a]	6,955	3,573	29,648	[a]	[a]	[a]
Facility HVAC	50,220	60,264	[a]	8,694	4,466	37,060	10,433	5,359	44,472	[a]	[a]	[a]
Facility Lighting	50,220	[a]	[a]	8,694	4,466	37,060	[a]	[a]	[a]	[a]	[a]	[a]
Other Facility Support	10,044	[a]	[a]	1,739	893	7,412	[a]	[a]	[a]	[a]	[a]	[a]
Onsite Transportation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Conventional Electricity Generation	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Other Nonprocess Use	[a]	10,044	[a]	[a]	[a]	[a]	1,739	893	7,412	[a]	[a]	[a]
End Use Not Reported	10,044	[a]	[a]	1,739	893	7,412	[a]	[a]	[a]	[a]	[a]	[a]
Total	703,083	662,907	2,521,056	121,716	62,525	518,842	114,761	58,952	489,194	436,438	224,197	1,860,421

a Denotes instances where there was not enough information to impute a value.