A Tough Nut to Crack: What will it take to decarbonize industrial facilities?

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With thanks to

- NYSERDA staff
  - Industrial program team
  - Advanced technologies team
  - Evaluation team
  - Integration Analysis Team
  - Thermal Network Team
  - Policy Team
  - Hydrogen Team
- Study Advisory Board

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Overview

- Background
- NYS Industrial Facilities Characterization
  - Methods
  - Key Results
- NYS Industrial Decarbonization Potential Study
  - Methods
  - Key Results
- Conclusions

Background

The Challenge

- Manufacturing sector energy use is about 1/3 of primary energy use in the United States,
  mostly fossil fuels
- Decarbonizing manufacturing production is challenging:
  1. Highly diverse processes, equipment, inputs products
  2. Change risks include lost production time, product quality effects, workforce and work practices

Addressing the Challenge

Granular understanding of manufacturing sector composition and opportunities is needed for effective program targeting

Studies sponsored by NYSERDA:

1. NYS Industrial Facilities Stock Study (December 2023) "The Stock Study" (Published at https://www.nyserda.ny.gov/About/Publications/Evaluation-Reports/Building-Stock-and-Potential-Studies)
2. NYS Industrial Decarbonization Potential Study (2025) "The Potential Study" (Will be published soon)

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Industrial Facilities Characterization

Methods: Industrial Stock Study, Phase 2

Web Survey and Eligibility

- **Internet-based survey** supported by phone outreach.
- Completed **603 Industrial** surveys.
- NYSERDA and secondary sources were used to **maximize response rates.**
- **Facilities screened** to confirm manufacturing activity at site.
- **Energy consumption** data requested via bills or consent to receive them.

Onsite Surveys

- Industrial and greenhouse facilities were **recruited for more detailed data collection.**
- **107 industrial sites and 13 greenhouses** received a physical or virtual visit.
- This data collection included **interviews** with facility staff, **equipment inventories** (time permitting), and other site observations.

Sample and Weighting

- **Adjusted the population** of manufacturing facilities to account for those without manufacturing operations.
- **Developed weights** for analysis based on achieved survey completes representing various NAICS subsector and size (by fuel expenditure) strata.

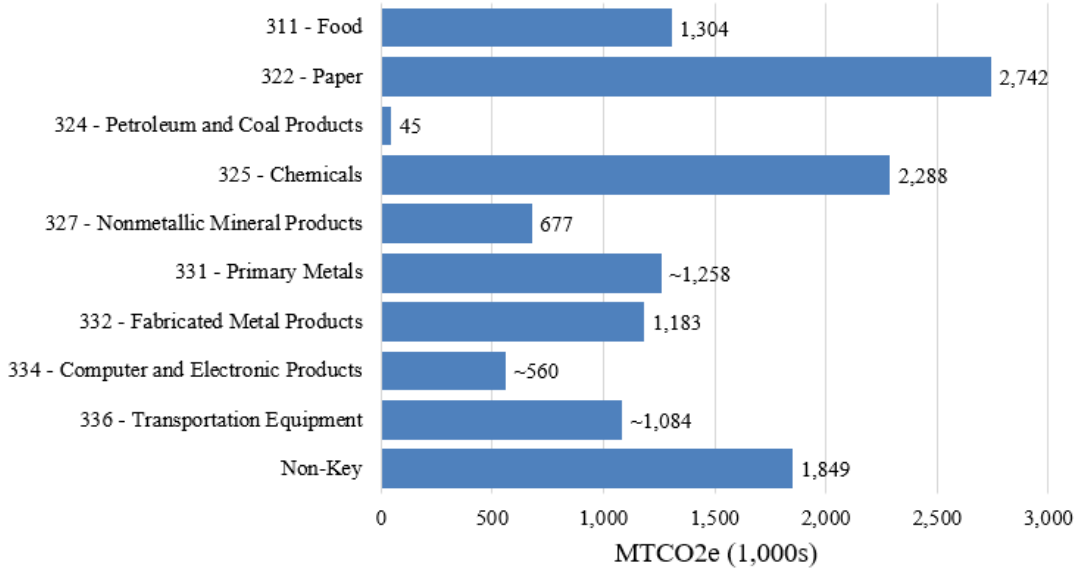
Analysis and Reporting

- **Imputed values for missing cases of fuel expenditures or energy consumption** based on average fuel costs from respondents.
- **Summarized weighted data** to describe firmographics, energy consumption, energy expenditures, and GHG emissions by NAICS subsector and size.

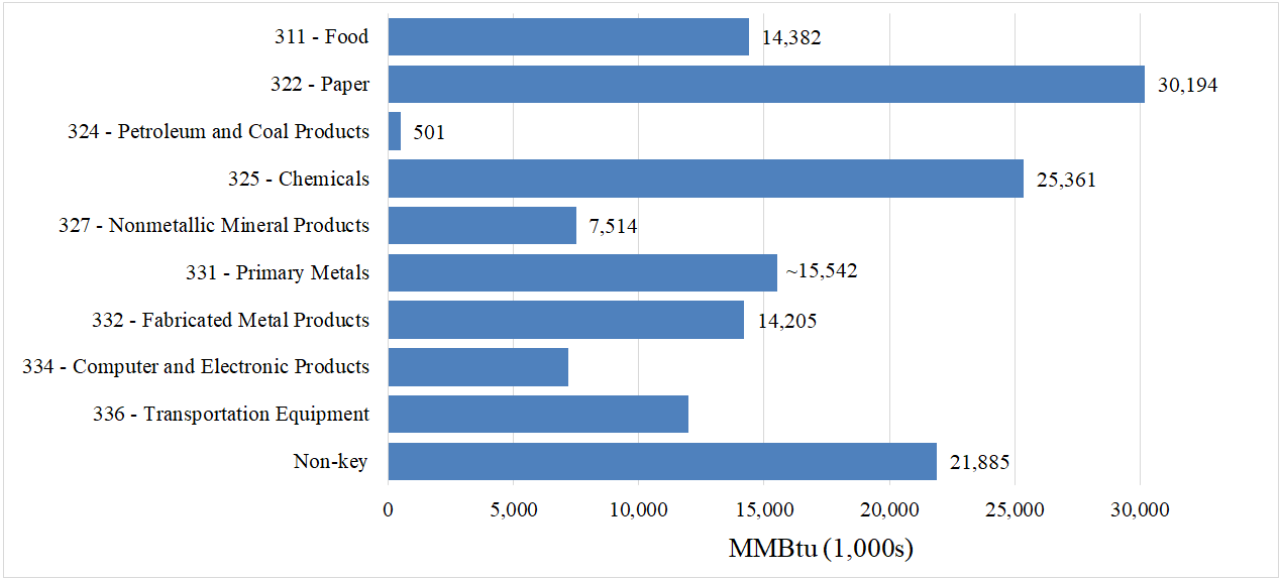
Results: Energy use and GHG emissions show similar patterns across subsectors

- Only includes facilities with confirmed manufacturing activity
- Paper and Chemicals represent nearly 40% of both annual energy consumption and emissions.

Emissions (1,000s MTCO2e)



Energy consumption (1,000's MMBtu)



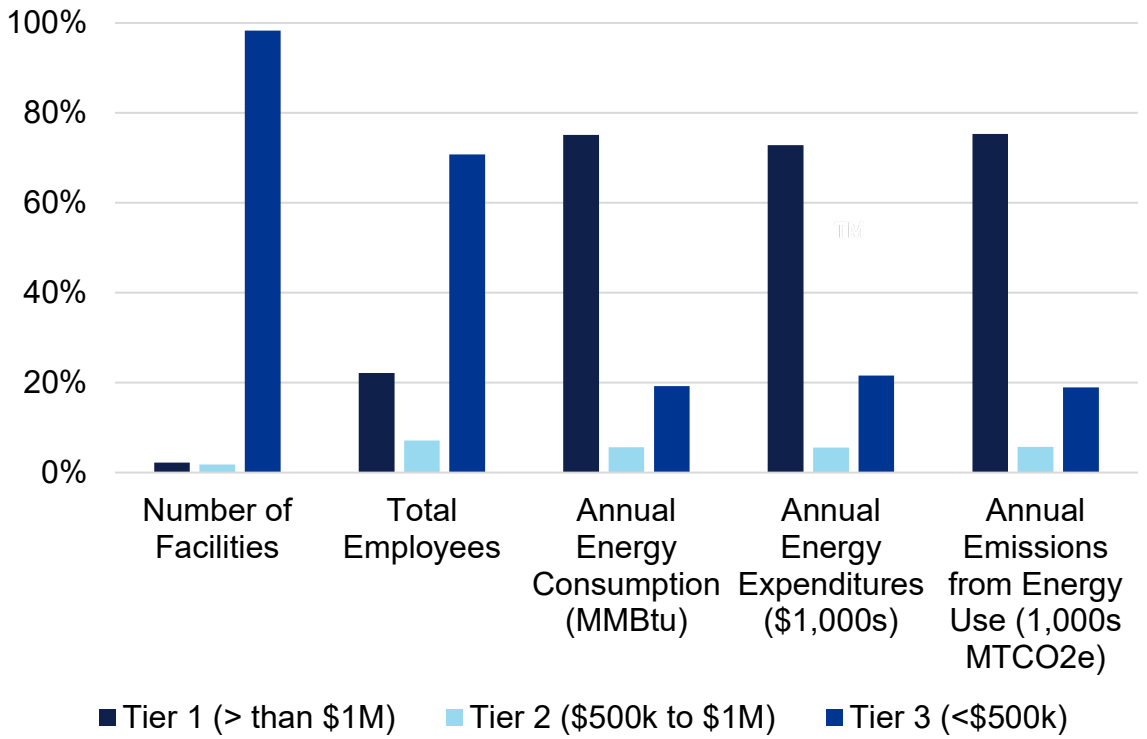
~: result either has a single weighted response representing more than 50% of a given aggregate calculation or has an RSE between 50% and 100%

Results: New York State has a relatively small group of large, energy-intensive manufacturers

- Tier 1 contains 2% of total facilities but 75% of energy use, expenditures, and emissions.
- Small manufacturing operations are far more numerous but less energy intensive
- Tier 3 is estimated to have 98% of total facilities but 19% energy use and emissions.

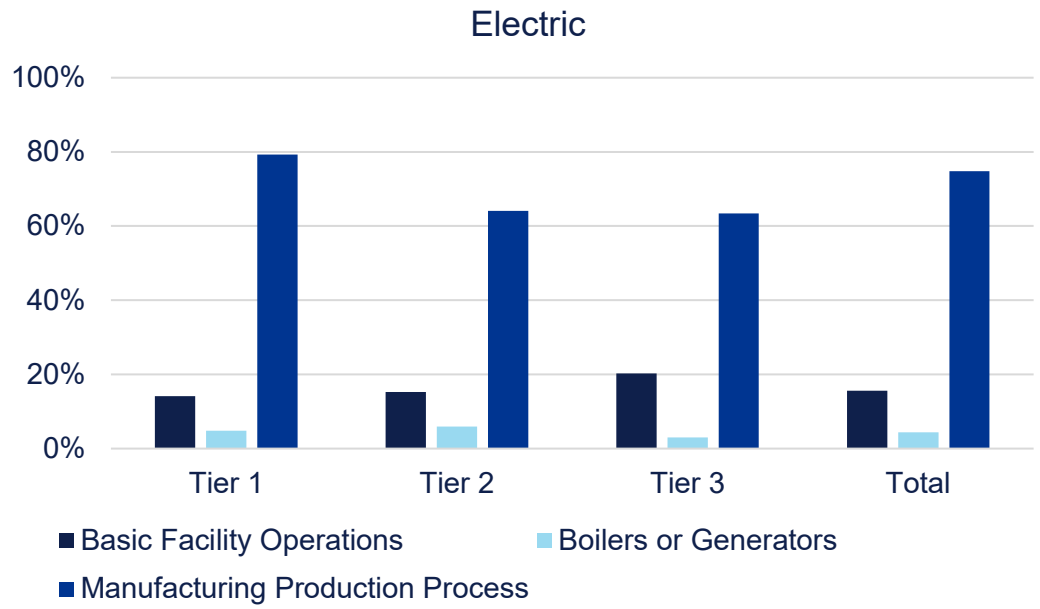
Key metrics by expenditure tier

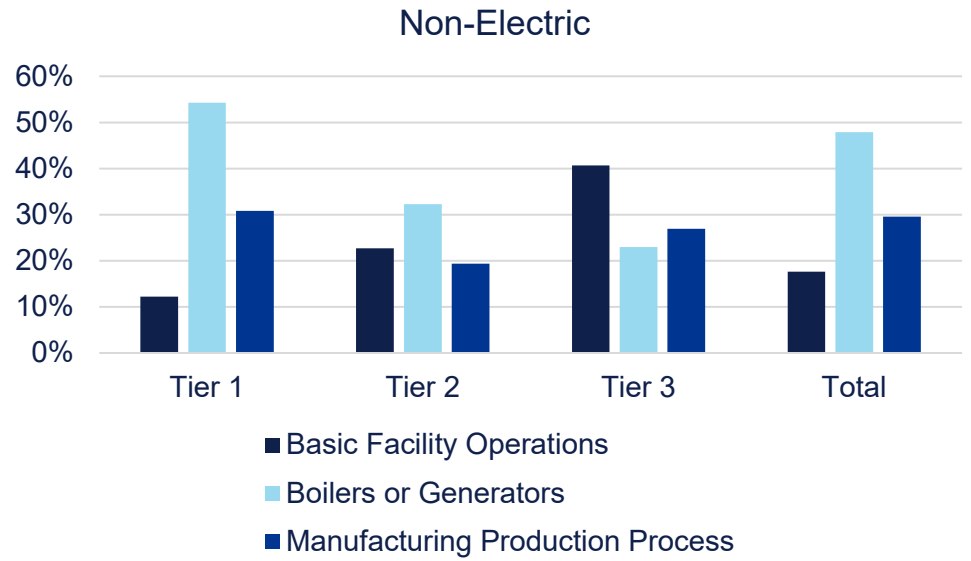
Number of Facilities	Total Employees	Annual Energy Consumption (MMBtu)	Annual Energy Expenditures ($1,000s)	Annual Emissions from Energy Use (1,000s $MTCO_2e$)
7,777	**327,622**	**148,733,079**	**1,788,634**	**12,990**



Results: Most electricity is used for production processes

- Three-quarters of electricity is used for production processes.
- Roughly half of non-electric fuels are used for boilers and 30% is used for production.
- Approximately 15% of electric and non-electric fuels are used for basic facility operations





80% of non-electric fuels used for boilers provide heat at <570°F.

Industrial Decarbonization Potential

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Methods for industrial decarbonization potential are and aren't like those for a typical efficiency potential study

Economic inputs from public sources

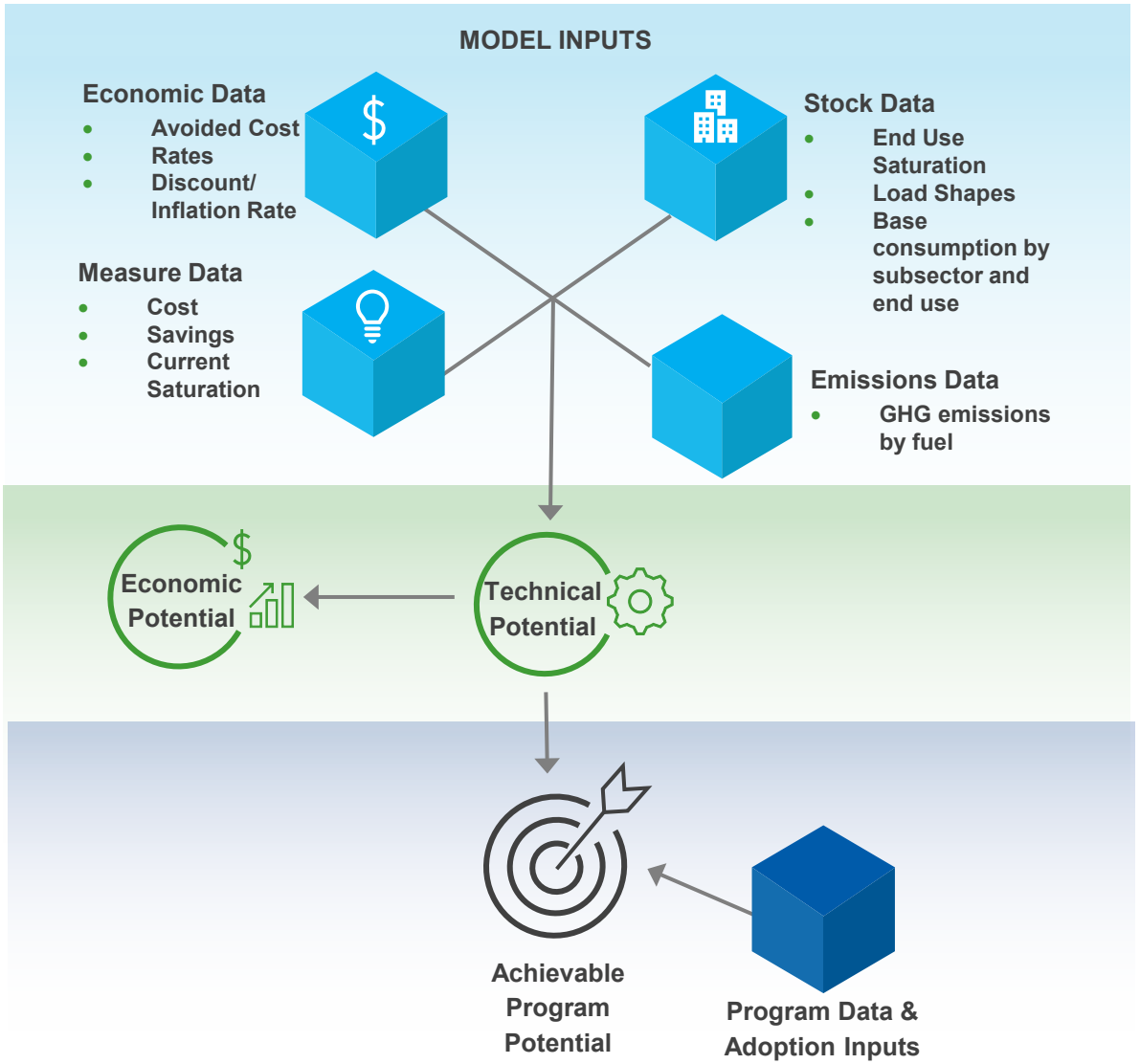
Measures specific to industrial facilities, many specific to individual industries

Measures span 4 decarb categories

Technical = Everything technically possible

Economic = Everything that's cost-effective

Achievable = What's likely to be adopted



Recent stock data, including multiple fuels

Subsectors are specific industries

Potential estimated is GHG emissions reductions

Scenarios

Achievable wasn't constrained by what's societally cost-effective

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Methods: Adoption Scenario Definitions
Compared to Base Case

Key Assumptions	Base	Site Incentive	Carbon Price	Carbon Price +
Hydrogen Price	Hydrogen price forecast that takes into account IRA production tax credit	Base	Base	Altered hydrogen price forecast that assumes that NY steps in as the IRA tax credit phases out to keep the hydrogen price low
Carbon Price	No emissions cap set and Cap and Invest carbon price is 0	Base	Carbon price	Carbon price scenario
Incentive Levels	Set to zero	Incentives reduce IRR for each measure	Site Incentive scenario	Site Incentive scenario
Program Marketing Budgets* (increases awareness)	Set to zero	$155k	$2,770k	$2,770k initially, increasing with revenue from the C price
Market Barriers	Assumptions vary by measure, but do not change over time	Base	Base	Base assumptions initially, lowered over time for electrification, LCF and CCUS

- Measure adoption competition methodology
  - All measures with technical potential are considered for adoption
  - Measures with higher customer B/C get relatively more adoption, those with low B/C get relatively less
  - Technical and economic potential are “winner take all,” where only the measure with the highest potential beats out competing measures

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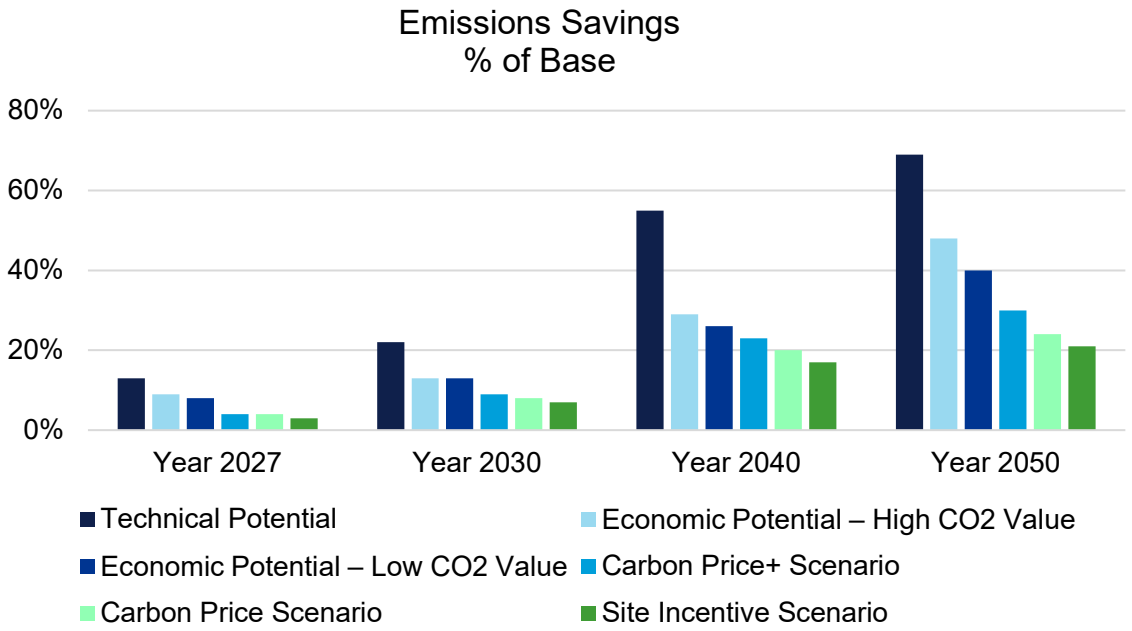
Results: Summary of Potential Estimates

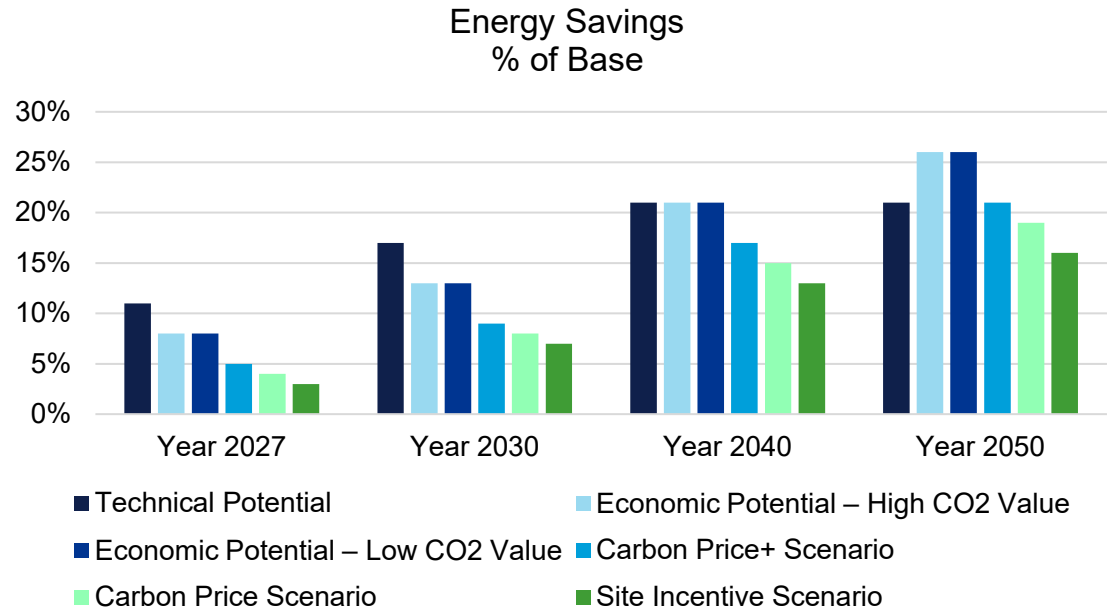
Baseline Emissions (thousand MTCO2e)

2027	2030	2040	2050
18,175	15,981	13,123	13,921



Baseline Consumption (million MMBtu)

2027	2030	2040	2050
176	178	186	201



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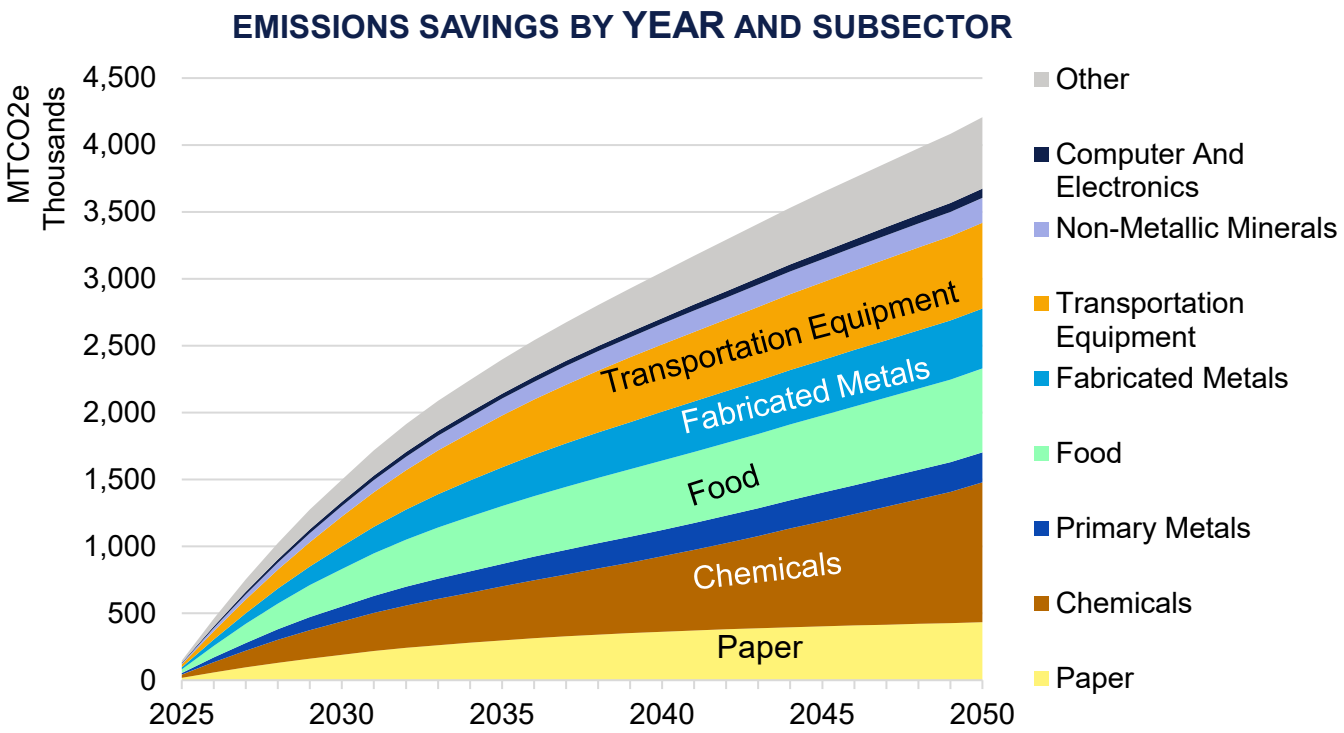
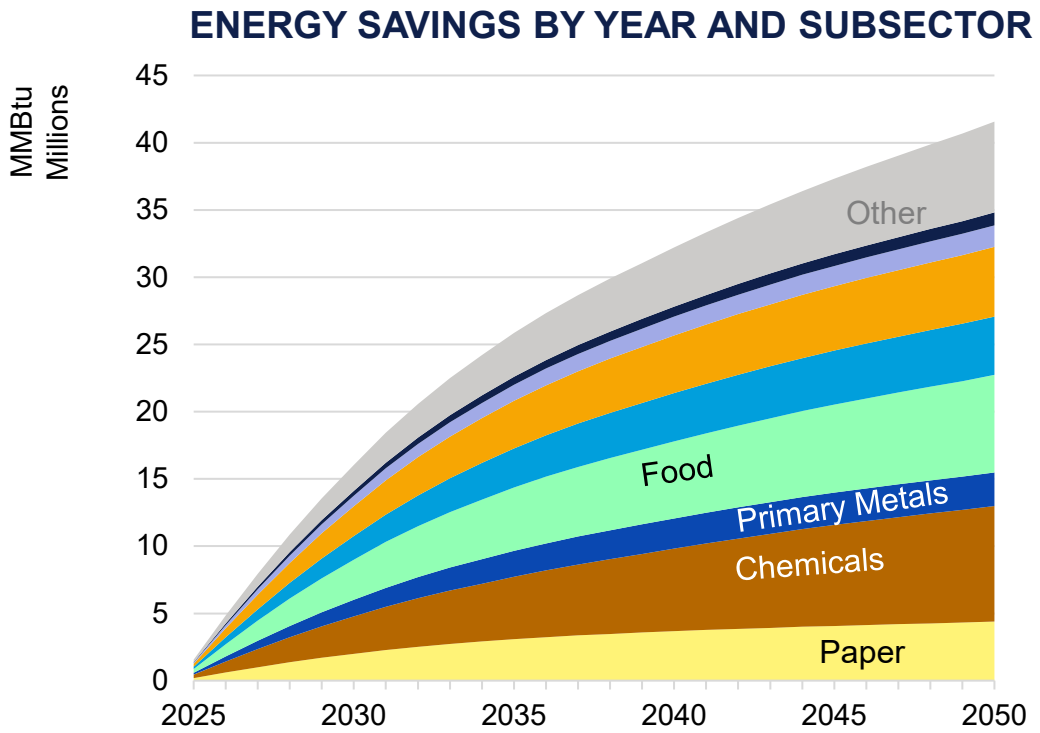
Results: Carbon Price+ Scenario
Achievable Potential by Subsector

- Largest baseline energy and emissions subsectors are largest contributors to savings
- Share of potential by each subsector remains relatively unchanged across the adoption scenarios

2022 Baseline Totals by Subsector	*Emissions (thousand MtCO2e)	*Energy Consumption (mill. MMBtu)
Paper	3,224	30.2
Chemicals	3,425	34.9
Primary Metals	2,251	16.2
Food	1,505	14.5
Fabricated Metals	1,590	14.2
Transportation Equipment	1,200	12.1
Non-Metallic Minerals	1,633	7.5
Computer And Electronics	974	7.3
Other	2,470	30.8
Total, 2022	**18,270**	**167.6**





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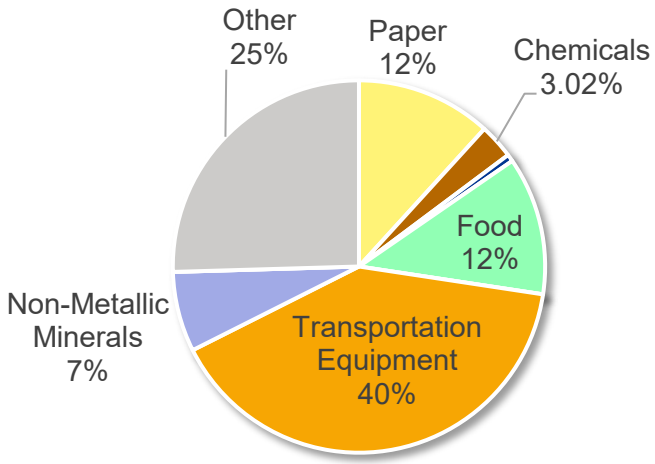
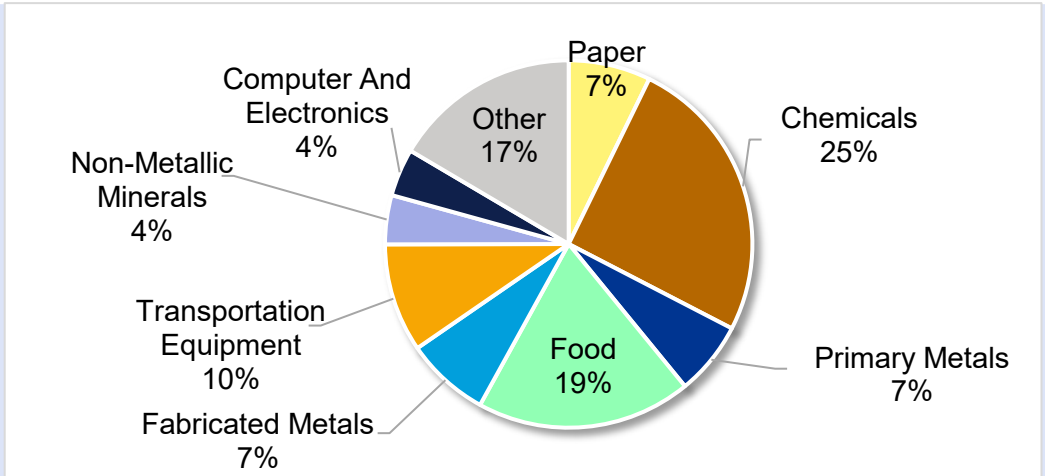
Results: Mix of potential categories differs by industrial subsector

Carbon Price+ Scenario, % of Total 2050 Achievable Emissions Savings Potential by Subsector

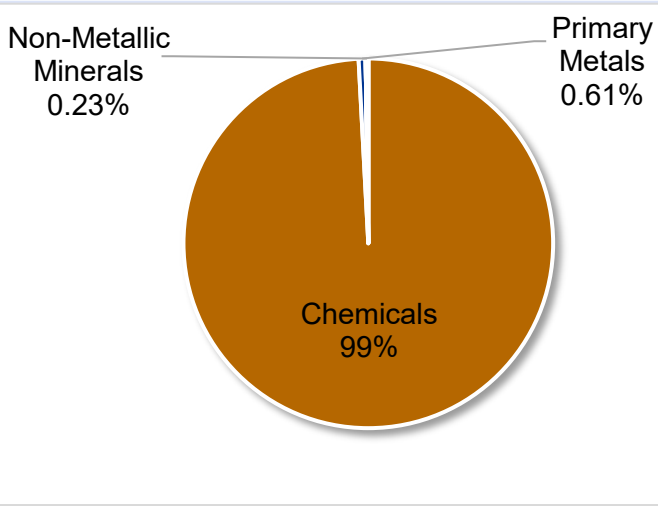
LOW CARBON FUELS= 1,428 MTCO2E



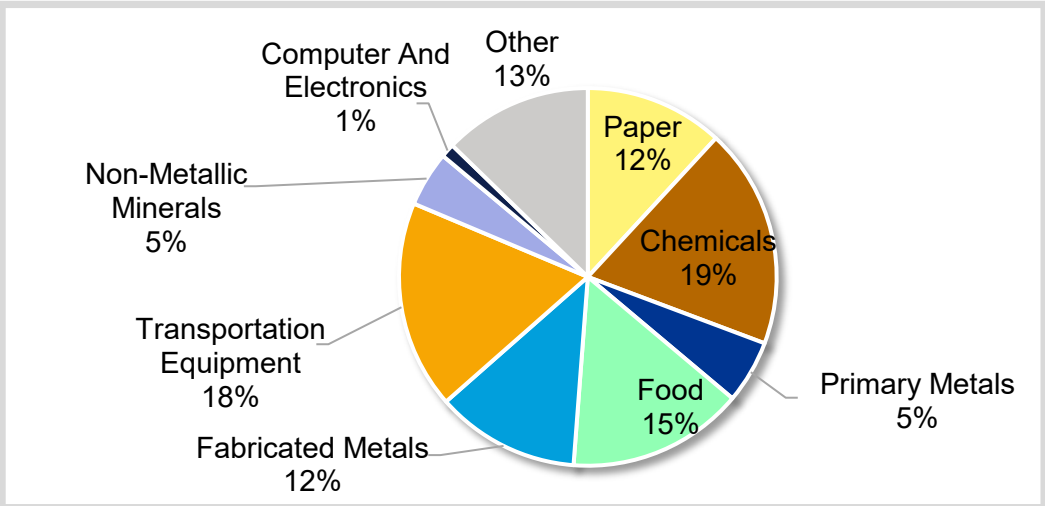
ENERGY EFFICIENCY= 777,962 MTCO2E



CCUS= 250,856 MTCO2E

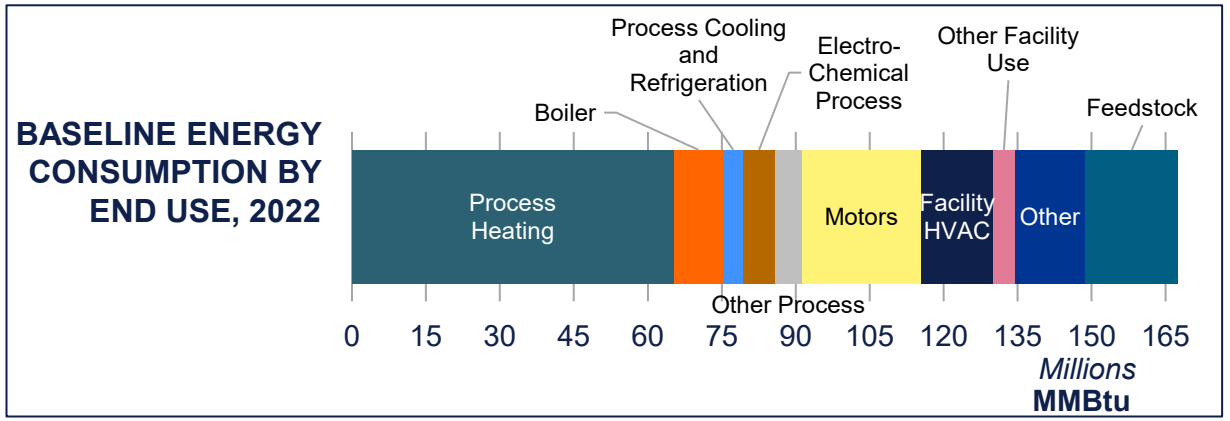


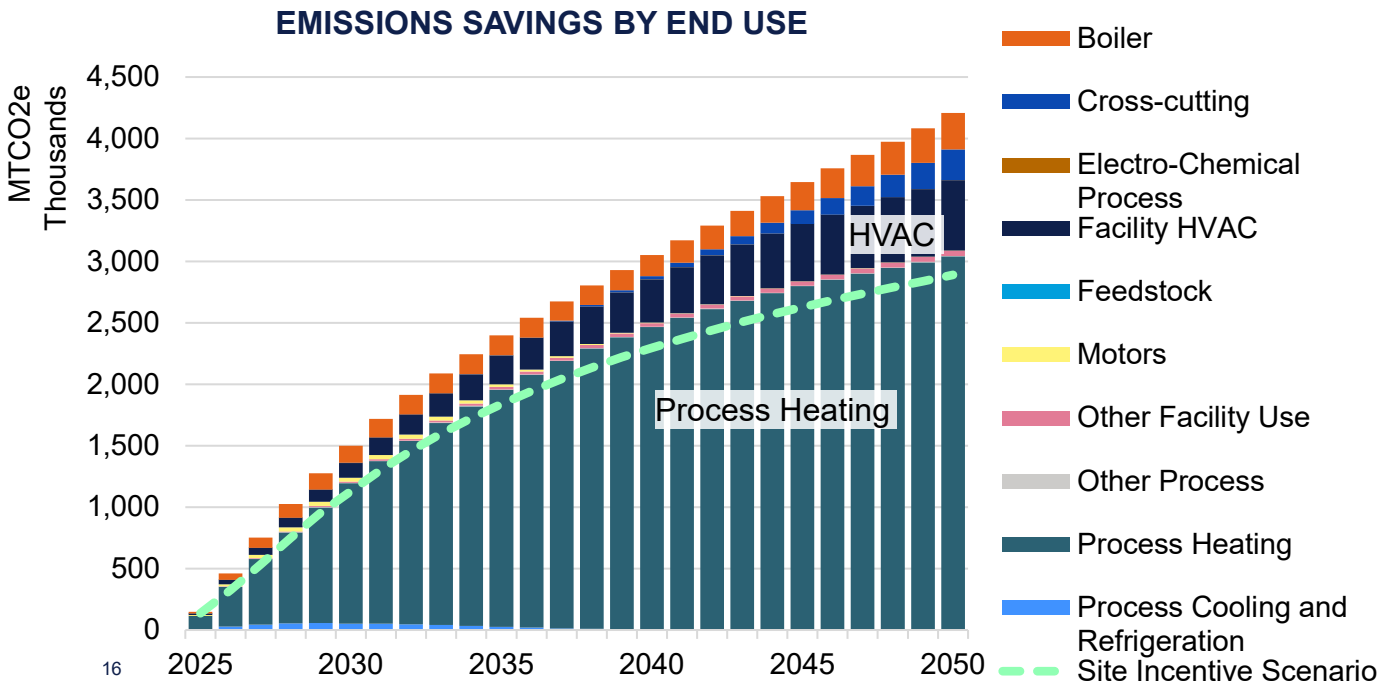
ELECTRIFICATION= 3,177,298 MTCO2E

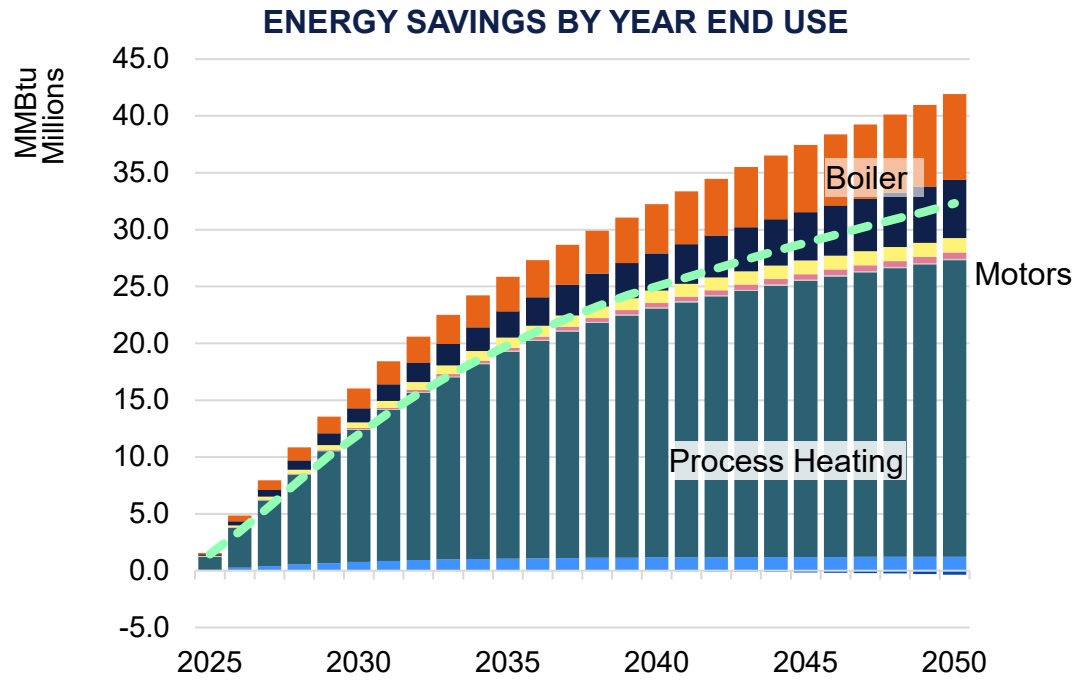


Results: By end use, Process Heating dominates achievable emissions & energy potential

- 2050 potential by end use for the Carbon Price+ scenario
- Motor efficiency measures save energy but not carbon
- Net negative energy savings for cross-cutting measures due to increased electricity use with CCUS.







Conclusions: Knowing the Population

- **Getting the data**
  - Substantial resources and time are needed to establish the population of actual manufacturing facilities.
  - Detailed, meaningful data on the industrial sector is possible when the necessary resources and methods are applied.

- **Describing the population**
  - Energy use varies substantially across and within industrial subsectors.
  - The segments and subgroups with higher total energy use also tend to have higher emissions and higher savings opportunities, but the specific energy uses and opportunities vary
  - Understanding the particular processes within the state allows more effective design and targeting of program offerings.

Conclusions: *There remain substantial opportunities within the state for continued shaping of energy management practices, policies, and awareness of energy use within facilities*

- **Where are the emissions savings opportunities?**
  - A small fraction manufacturers account for the majority of energy use, emissions, and savings opportunities
  - Electrification accounts for more than three-quarters of achievable emissions reduction potential across all achievable scenarios.
    - In several key subsectors, low- and medium-temperature heating (under 570°F) account for large portions of fossil fuel use. These processes are potential candidates for electrification.
  - Low-carbon fuels have the highest technical potential for GHG emissions savings, but modest economic potential, and minimal adoption.

Selective, systematic interventions with manufacturing facilities can meaningfully reduce GHG and benefit both industrial customers and NYS residents

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Thank you. Questions?

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