HFC Transition in The Grocery Industry

AN UPDATED ASSESSMENT

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Executive Summary

In July 2023, we (along with our colleague Mark Berkman) assessed the economic impacts of the proposed EPA rule, "Technology Transitions Restrictions on the Use of Certain Hydrofluorocarbons Under Subsection (i) of the American Innovation and Manufacturing Act" ("Brattle 2023 Report"). The proposed rule was updated and finalized in October 2023 ("Final Rule"). We have been asked to revisit our analysis to reflect the requirements under the Final Rule, evolving refrigeration technologies, and current economic and policy environments affecting compliance.

As part of our assessment, we reviewed industry documents and economic data and conducted interviews with industry representatives. This work confirmed the overall conclusions of our initial report and identified additional headwinds that further complicate compliance.

Continuing Impacts and Challenges

- **Higher Capital Costs.** Compliant systems, notably those based on transcritical CO_2, cost roughly 25-40% more than traditional refrigeration systems.
- **Energy and Environmental Trade-offs.** While energy costs of compliant systems may be comparable to traditional systems in cooler climates, they are significantly higher in regions designated by the EPA as "less viable" for CO_2 systems. Mitigation via adiabatic gas cooling increases water consumption, raising utility costs and negatively impacts environmental resources.
- **Increased Maintenance Expenses and Downtime.** A shortage of qualified technicians for transcritical CO_2 systems is expected to increase labor costs, maintenance expenses, and store downtime, leading to more food waste and lost sales revenue.
- **Competitive Industry.** The grocery industry is highly competitive with low margins, currently under 2%.
- **Limited Capital.** Owing to low margins, capital is relatively scarce in the grocery industry. This constraint limits the ability to fund projects burdened by higher capital costs, reducing grocers' ability to expand or upgrade refrigerated sections. This slows store openings and modernization efforts.
- **Higher Consumer Prices.** Given the highly competitive nature of grocery retail, increased costs, especially those related to operations and maintenance, will largely be passed on to

consumers; empirical studies indicate pass-through rates in the grocery industry of at least 50-60%.

- **Less Healthy Choices.** Because fresh foods are more likely to require refrigeration, the cost increases will mostly be reflected in prices for these items, including fruits and vegetables, meats, seafood, and cheese. Because implementing compliant systems would require replacing traditional systems entirely, stores will be disincentivized from expanding existing offerings, reducing consumer choice. Additionally, shelf-stable processed foods will become relatively cheaper, shifting consumer diets toward these less healthy options.
- **Impacts to Rural Areas.** Price impacts are likely to be higher and disincentives to opening of new stores stronger in rural areas, which are less likely to have technicians qualified to service transcritical CO_2 systems and have more price sensitive customers.
- **Impacts to Small- and Medium-Sized Businesses.** These price and expansion impacts are also likely to disproportionally affect small retailers, with less access to capital markets, and medium-sized businesses, which have been squeezed by big box retailers.

Additional Headwinds

- **Persistent Inflation.** Inflation has continued to exceed target levels: food prices have increased 25% since passage of the AIM Act. These higher costs squeeze both consumers and grocery retailers. Additional costs from aggressive HFC transition timelines would disproportionately impact middle-class and lower-income American families already struggling with rising living expenses.
- **Increased Tariffs and Trade Uncertainty.** Heightened tariffs threaten to further escalate food prices and squeeze retailer margins. Notably, Mexico and Canada are the largest exporters of agricultural products to the US and both countries have experienced sharp increases in tariffs. Additionally, compliant refrigeration systems depend heavily on imported components that may be subject to tariffs, exacerbating cost pressures.
- **Rising Interest Rates.** Interest rates have increased since passage of the AIM Act, with rates on 30-year US Treasury bonds increasing from 1.7% to nearly 5%, indicating higher borrowing costs for capital-intensive refrigeration projects.

Recommendations for a Practical Compliance Timeline

- **Market-Driven Efficiency.** The general phaseout of HFCs is leading to higher HFC prices. This regulation alone incentivizes retailers to transition away from HFC-based systems and to do so as efficiently as possible. In particular, it prioritizes implementing alternative (i.e., compliant) systems in new stores while using transitional gasses for standard, in-store expansions and retrofits. It also encourages adoption to begin where it is most viable, such as cooler climates and in urban areas.
- **Fostering Manufacturing Capacity and Capabilities.** This phased adoption approach supports the entry of new manufacturing firms and fosters innovation, further reducing costs through economies of scale and learning-by-doing. New technologies could be developed that are both compliant and more effective in areas that struggle with the viability of transcritical CO_2 systems.
- **Workforce Development.** Extending the compliance timeline would allow critical time for workforce training programs, helping develop a skilled labor pool of specialized technicians. This would mitigate labor shortages, reduce maintenance costs and timelines, and improve the reliability of installing and servicing compliant refrigeration systems.
- **Cost Management.** As compliance begins with the most cost-effective projects, the affordability of compliant technologies will improve over time, smoothing the transition process and reducing economic disruptions.
- **Building Code Adjustments.** An extended timeline also enables state and local governments to update their building codes to ensure that grocers can adopt the most effective compliant technologies.

In summary, we advocate for regulatory standards that provide clear, achievable objectives, offering certainty in compliance expectations while remaining realistically attainable for the grocery industry. Adjusting the compliance timeline to reflect economic realities will encourage innovation, provide opportunities for worker training, limit unnecessary consumer price increases, and protect American businesses.

I. Introduction

In December 2022, the US Environmental Protection Agency ("EPA") published a proposed rule titled "Technology Transitions Restrictions on the Use of Certain Hydrofluorocarbons under Subsection (i) of the American Innovation and Manufacturing Act" ("Proposed Rule"), which proposes to restrict the use of certain higher-global warming potential ("GWP") hydrofluorocarbons ("HFCs") in refrigeration by various sectors and subsectors, including the retail grocery industry. Our we, along with our colleague Mark Berkman, were asked to review the Proposed Rule and discuss its economic implications, which we provided in a July 2023 report.

The rule was finalized in October 2023 ("Final Rule").[1] The Final Rule incorporates some changes from the Proposed Rule, notably in the compliance timeline. We were asked to review the Final Rule and update our report to reflect these changes as well as evolving refrigeration technologies and current economic and policy environments that may affect compliance.

As drafted, the Final Rule would generally prohibit the use of the restricted HFCs in the grocery industry for new applications such as new stores and remodels by January 1, 2025 and, in some cases, by January 1, 2028. For the retail food refrigeration sector specifically, the Proposed Rule establishes a GWP limit of 300 for refrigeration systems in supermarkets with charge capacities less than 200 pounds and a GWP limit of 150 for systems with refrigerant charge capacities of 200 pounds or greater, along with a compliance deadline of January 1, 2027. Remote condensing units, often used to supplement larger refrigeration systems, have similar GWP phasedown restrictions, however the Proposed Rule requires that these targets are met by January 1, 2026. These GWP limits are purportedly supported by the EPA's evaluation of costs as presented in the Regulatory Impact Analysis accompanying the Proposed Rule.

The Final Rule is itself layered on top of another regulation published by the EPA first enacted on December 27, 2020 and most recently updated as the "Phasedown of Hydrofluorocarbons: Allowance Allocation Methodology for 2024 and Later Years." This rule implements a requirement in the American Innovation and Manufacturing Act to phase down HFC use, culminating in an 85% reduction by 2036.[2] The Act directs the EPA to implement this

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1 "Phasedown of Hydrofluorocarbons: Restrictions on the Use of Certain Hyrdofluorocarbons under the American Innovation and Manufacturing Act of 2020," EPA, October 2023, https://www.govinfo.gov/content/pkg/FR-2023-10-24/pdf/2023-22529.pdf

2 "Phasedown of Hydrofluorocarbons: Allowance Allocation Methodology for 2024 and Later Years," EPA, July 2023, https://www.govinfo.gov/content/pkg/FR-2023-07-20/pdf/2023-14312.pdf, p. 2.

phasedown by determining the annual allowable total HFC consumption and issuing that quantity of transferrable production and consumption allowances each year. Put differently, the EPA is tasked with setting quantities in a market for HFC production and use over time.

In its regulatory analysis of the Final Rule, the EPA claims that the proposal will *reduce costs* in the grocery industry. The Agency reaches this conclusion for two reasons. First, it assumes that compliant systems are more energy efficient, leading to annual operating savings of over $11,000 per store each year.[3] Second, it assumes that the cost of CO_2 or ammonia for use in compliant systems is "negligible" in comparison to the $9 per kilogram cost assumed for R-404A systems.[4] Put differently, the EPA assumes that no matter how "leaky" the compliant systems are, they can be refilled costlessly; this assumption leads to a savings estimate of approximately $2,000 per store per year.[5] These assumed reductions in ongoing operating costs outweigh EPA's assumed capital costs of installation; in fact, the EPA assumes that these systems would pay for themselves within 3 years.[6] As a result, the Final Rule is found to benefit the grocery industry.

To assess the reliability of the EPA's assumptions and conclusions, we have reviewed publicly available documents and interviewed industry representatives. Specifically, in updating our report, we have spoken with representatives of 5 grocery companies, comprising over 3,000 stores across all 50 states; three of these companies are part of the EPA's GreenChill program that aims to reduce the environmental impact of refrigeration systems in grocery stores.[7] We also reviewed *The Food Retailing Industry Speaks* report produced by FMI.[8] This report has been compiled for over 75 years and provides a snapshot of the state of the grocery industry.

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3 "Regulatory Impact Analysis Addendum: Impact of the Technology Transitions Rule," EPA, September 2023, Table 4-2, https://www.epa.gov/system/files/documents/2024-11/epa-hq-oar-2021-0643-0227_attachment_1.pdf ("EPA RIA Addendum"); "Economic Impact Screening analysis for Restrictions on the Use of Hydrofluorocarbons under Subsection (i) of the American Innovation and Manufacturing Act," EPA, November 2022, Table 4 ("EPA Small Entity Assessment").

4 EPA Small Entity Assessment, Table 5.

5 "Regulatory Impact Analysis for Phasing Down Production and Consumption of Hydrofluorocarbons (HFCs)," EPA, September 2021, p. 47, https://www.epa.gov/system/files/documents/2022-07/RIA%20for%20Phasing%20Down%20Production%20and%20Consumption%20of%20Hydrofluorocarbons%20%28HFCs%29.pdf ("EPA RIA").

6 EPA RIA Addendum, Table A-5; EPA Small Entity, Table 5.

7 "GreenChill Keeping Cool for Fifteen Years, 2007-2022," EPA, https://www.epa.gov/system/files/documents/2022-09/GreenChill-Keeping-Cool-for-15-Years-2022_1.pdf.

8 "The Food Retailing Industry Speaks," FMI, 2024, https://www.fmi.org/our-research/research-reports/food-retailing-industry-speaks ("The Food Retailing Industry Speaks").

The 2024 report is based on a survey sent to US and Canadian food retailers in February and March 2024 and the 93 respondents represent over 38,000 stores.[9]

Overall, we conclude that the EPA's assumed capital costs dramatically understate those anticipated by the industry and the energy and refrigerant cost savings are overly optimistic, especially for warmer parts of the country (areas that the EPA describes as "less viable" for its only modeled compliant system).[10] Instead, we find that the Final Rule will impose substantial costs on the industry. These costs would represent a difficult burden on a low margin, competitive industry and would be passed on at least partly to consumers through higher grocery prices.

These costs could be mitigated by pursuing a market-driven approach. The economy-wide phasedown of HFC production will lead to higher refrigerant prices, inducing technology transitions first where they are most cost effective. During this process, additional equipment and gas manufacturing capabilities can become established, reducing the costs of the alternative systems. Furthermore, technicians can gain the skills necessary to service the new systems. Lastly, local building codes can be updated to expand the range of alternatives available. This approach provides a cost-effective pathway for the technology transition.

In our report, we focus on transcritical CO_2 as the primary compliant technology currently available. There are several reasons for this focus. First, this is the only compliant technology that the EPA considers in its analysis for the grocery industry. Second, alternative compliant gases, such as A2L, are not approved under building codes across much of the country. Third, alternative systems are less proven and less widely available than transcritical CO_2 systems. Lastly, some industry representatives expressed concerns that GWP limits may be tightened further and view CO_2 (because it is naturally occurring with a GWP of 1) as essentially "future-proof." However, a longer compliance timeline could enable additional options to be developed and tested and for building codes to accept these alternatives.

[9] The Food Retailing Industry Speaks, p. 74.

[10] For the purpose of this report we focus on supermarket systems as laid out in the EPA analysis (EPA Small Entity Assessment, Table 4). The EPA only models the use of a CO_2-based system for the grocery industry (EPA RIA, p. 30). However, propane is listed as an acceptable substitute for standalone food refrigeration units.

II. The Final Rule Will Substantially Increase Costs, Reducing the Profitability and Viability of Stores

In its analysis, the EPA assumed that the incremental capital costs of transcritical CO_2 systems is low and that operating costs of these systems are lower than systems using traditional refrigerants. Taken together, the Agency finds that these systems pay for themselves within three years. Our discussions with industry representatives cast doubt on this conclusion, however.[11]

In this section, we first discuss the additional capital costs associated with these systems. While some companies may find these increases to be manageable for new stores, discussions with members of the industry indicate that retrofitting existing HFC systems to be compliant would be disruptive and costly, reducing the likelihood of store updates. Additionally, many stores will experience higher energy and refrigerant costs under the Final Rule, especially across the southern US. Because the grocery industry operates on low margins, these investments may not be justifiable, especially for low profitability stores, leading to store closures or averted openings.

A. Compliant Systems Are Currently Substantially More Costly Than Traditional Systems

From speaking with FMI members, we understand that transcritical CO_2 systems cost substantially more than traditional HFC systems. This is due both to higher equipment costs and higher installation costs. Based on our discussions, we understand the cost of a traditional HFC system to be approximately $3.6 million for a typical store (with an average size of 50,000 square feet). Those discussions also indicated that a transcritical CO_2 system has an approximately 30% cost premium, implying a $1.1 million cost difference for an average-sized store.

[11] See also: "Selecting the Right Refrigerant for Commercial Refrigeration," GlobalFact, September 2018, retrieved from https://ozone.unep.org/system/files/documents/GlobalFACT-whitepaper-%20FINAL.pdf ("Higher system costs more than offset low refrigerant cost," p. 10).

In its assessment, the EPA assumed that the additional cost of a compliant system would be $35,000 for a large (60,000 square foot) store, giving a cost of approximately $30,000 for an average-sized store.[12] This is far below the incremental capital cost projected by industry.

Furthermore, these costs do not include financing. Businesses typically do not pay for large capital expenses upfront; instead, they finance the project using debt (either by obtaining a loan or issuing bonds) or equity (selling shares in the company).[13] Considering the typical financing methods of publicly traded grocery companies, the average cost of this financing is 5.96%.[14] Given this rate, financing adds an additional $600,000 to the capital cost; hence, the total incremental cost of a transcritical system for an average-sized store is approximately $1.7 million.

Following our discussions with industry participants, we conclude that the EPA dramatically understated the cost of a compliant system in its assessment of the Final Rule.

B. Contrary to EPA's Assumptions, Many Stores Will Experience Higher Energy Use and Refrigerant Costs When Switching to CO_2-Based Systems

The EPA assumes that CO_2 systems will be more energy efficient than traditional HFC systems. This is highly dependent on the climate at the installed location, as noted in the EPA's own RIA. Specifically, the EPA indicates that regions with average annual temperatures exceeding 59 degrees or average annual high temperatures exceeding 88 degrees are "less viable" for transcritical CO_2 systems;[15] we identify these areas in the map below. Over 43% of the US population lives in these less viable areas.

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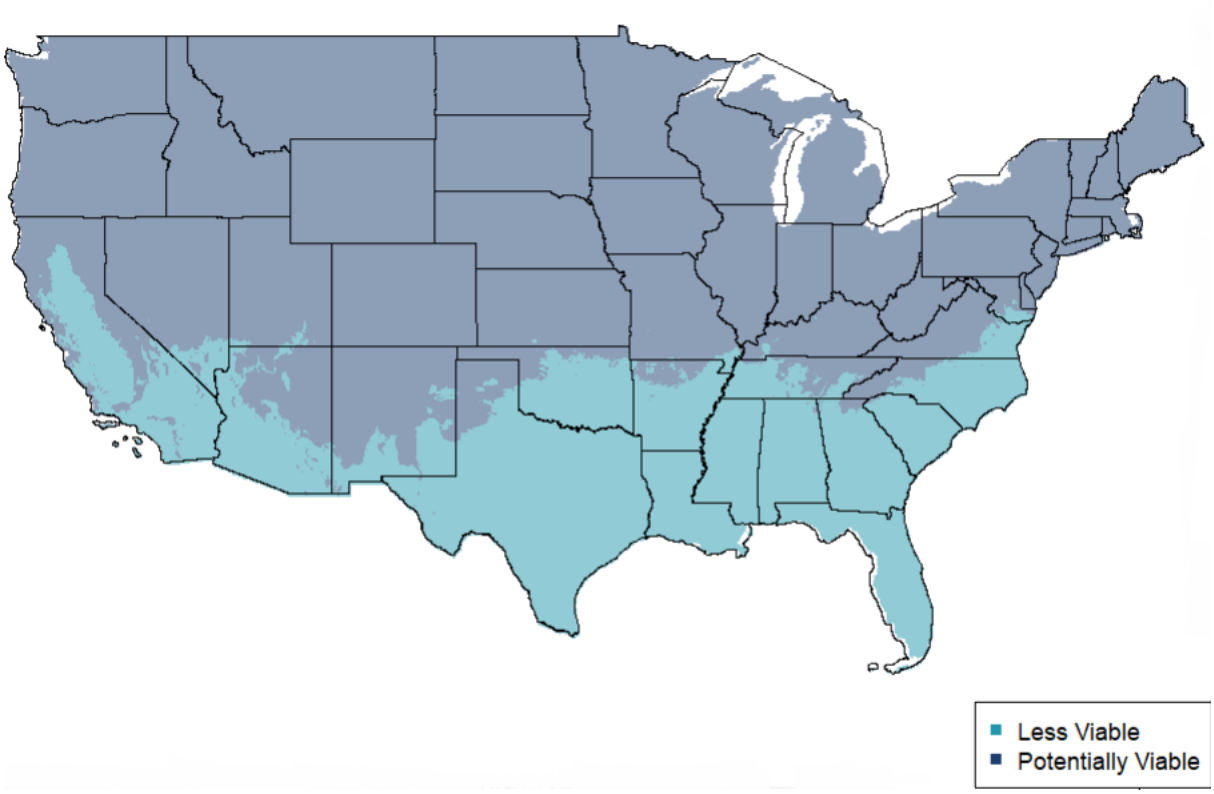
[12] EPA RIA, p. 47.

[13] Some companies may finance projects directly. The financing costs, then, should be considered the opportunity cost of foregone investment income due to the added expense.

[14] This figure is known as the weighted average cost of capital ("WACC"). It considers the cost, here specific to the grocery industry, of issuing debt and the cost of issuing equity. It then takes a weighted average of those values based on the share of debt relative to equity used by publicly-traded companies. As a result, the WACC represents typical financing costs based on the corporate finance decisions made by firms in the industry. 5.96% is taken from data last updated in January 2025 from NYU Cost of Equity and Capital (US) for "Retail Grocery and Food", https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/wacc.html.

[15] EPA RIA, p. 46. See also: "Selecting the Right Refrigerant for Commercial Refrigeration," GlobalFact, September 2018, retrieved from https://ozone.unep.org/system/files/documents/GlobalFACT-whitepaper-%20FINAL.pdf ("Significant efficiency issues in high ambient temperatures (very sensitive) translates to higher energy usage, demand charges, emissions and utility bills," p. 10).

FIGURE 1: POTENTIAL VIABILITY FOR CO_2 SYSTEMS BASED ON AVERAGE ANNUAL TEMPERATURE



Sources and Notes:
Potentially viable climates have an annual average temperature less than 59°F.
2021 Annual Mean Temperature dataset, PRISM, accessed July 17, 2023, https://prism.oregonstate.edu/recent/.

In its potentially viable areas, the EPA assumes that energy use will fall by 5% to 10%.[16] A prime test of this hypothesis is Hannaford's conversion of one store and opening of another using transcritical CO_2 in Maine. Instead of energy savings, Hannaford's Director of Energy and Facilities Services reported that energy use was 5% higher in the store with transcritical CO_2 than in similar stores using HFC refrigerants.[17] This example undermines the EPA's energy efficiency assumption even for its potentially viable areas.

Less amenable climates will generate even larger energy penalties for transcritical CO_2 systems. Northern California is a moderate climate, in that it is warm in the summer, but lacks humidity. Target compared two stores near one another in this region and found that its transcritical CO_2

[16] EPA RIA, p. 46.

[17] "Transcritical Update: Hannaford Supermarkets," R744, November 1, 2017, accessed July 27, 2023, https://r744.com/transcritical-update-hannaford-supermarkets/ ("Transcritical Update: Hannaford Supermarkets").

system used 20% more energy than the nearby HFC-based system.[18] In speaking with industry members, this increase is expected for all but the coolest northern climates.

Additionally, many transcritical CO_2 systems use an adiabatic gas cooler. This device uses water to pre-cool the air to lower the energy usage of the system. While these systems may cut expected energy increases in half, they require a substantial amount of water to operate; an average-sized store may need over 500,000 gallons of water for cooling. Stores in the EPA's less viable areas would require mitigation of energy consumption increases by implementing water cooling, but many of these areas also have experienced prolonged droughts and water shortages. Hence, adiabatic gas systems may exacerbate one environmental problem in trying to solve another. In addition to this environmental trade-off, this technology increases water utility bills in an effort to curb electric bills. Hence, they are far from an optimal solution.

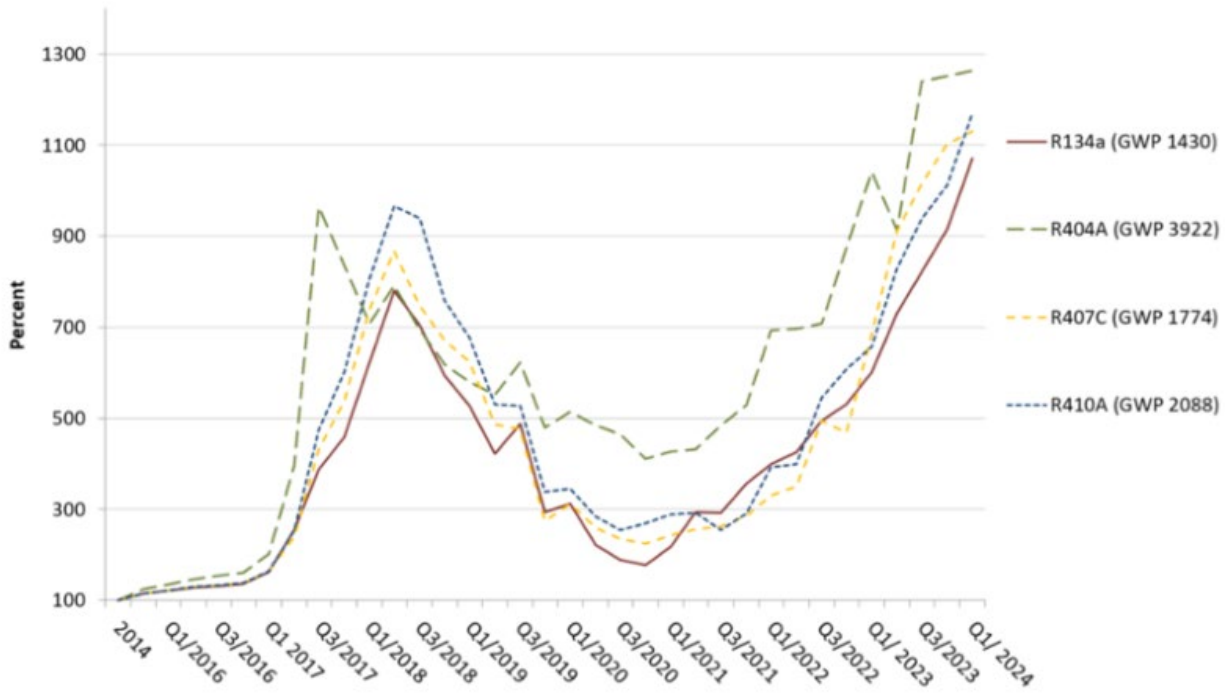
FIGURE 2: PRICE INDEX FOR CARBON DIOXIDE GAS

Sources and Notes:
FRED Economic Data, https://fred.stlouisfed.org/series/WPU06790302.

[18] Karim Amrane, "Reducing the Carbon Footprint of Commercial Refrigeration Equipment," globalFACT, December 2, 2019, p. 3, https://www.globalfact.org/wp-content/uploads/2019/12/globalFACT-MaintenanceEfficiency-White-Paper-2.pdf.pdf.

Lastly, the EPA incorrectly assumes that the price of CO_2 is "negligible." Instead, the price of CO_2 gas has nearly doubled in less than a decade with prices continuing to escalate, as witnessed in Figure 2 below. The price of high GWP HFC gases has also increased, at least partly in response to Europe's F-Gas regulations constraining the supply of these refrigerants as well as the limits imposed under the AIM Act, as shown in Figure 3 below.[19] The HFC gas price increases will spur a market-driven change to new, lower GWP technologies.

FIGURE 3: PRICE INDEXES FOR HIGH GWP HFC GASSES IN EUROPE



Sources and Notes:
"High GWP Refrigerants Face Soaring Prices as Natural Alternatives Offer Stability," January 10, 2024, accessed May 23, 2025, https://www.green-cooling-initiative.org/news-media/news/news-detail/2024/10/01/high-gwp-refrigerants-face-soaring-prices-as-natural-alternatives-offer-stability.

[19] Cooling Post, "2017 ends with 60% price rise," November 26, 2017, accessed July 27, 2023, https://www.coolingpost.com/uk-news/2017-ends-60-price-rise/. See also, EIA, "EU F-Gas Regulation Handbook: Keeping Ahead of the Curve as Europe Phases Down HFCs," September 2015, https://eia-international.org/wp-content/uploads/eia_euf-gas_eng_medrez.pdf.

C. Low Industry Margins Reduce the Ability of Stores to Absorb These Costs

Under standard economic theory, firms are less capable of passing capital expenditures on to consumers. Instead, these investments are paid using firm profits. As we demonstrate below, profit rates in the grocery industry are low, which limits the ability of stores to absorb capital cost increases that stem from the Final Rule.

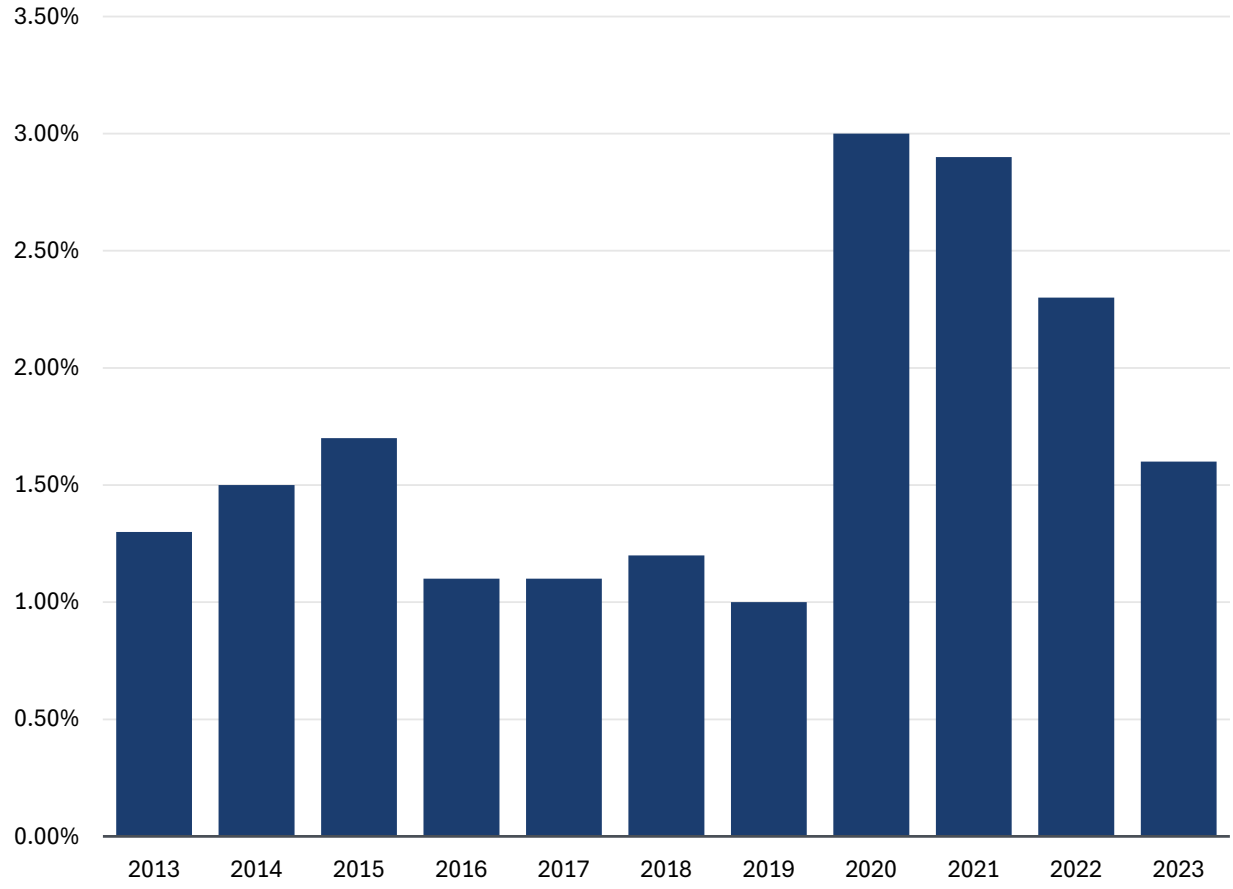
In general, the grocery industry is highly competitive, with stores representing a range of price points, shopping experiences, and product variety. Conventional grocery stores, such as Safeway, compete against higher-end stores like Whole Foods, big box stores like Walmart Supercenters, and small local markets. Because of this varied competition, the grocery industry has low profitability.

Figure 4 below shows typical net income rates for grocery stores over the past 11 years.[20] These rates have varied between 1% and 3%. The most recent data indicate a post-pandemic slide in profitability; net income was unusually high at the start of the pandemic, then fell as post-pandemic inflation accelerated. Consistent with these low rates, grocery stores tend to make their money on volume and less on the margin.[21]

[20] Net income subtracts all expenses, including capital expenditures, operations and maintenance costs, and taxes from revenue. The net income rate divides net income by revenue.

[21] Barbara Bean-Mellinger, "What is the Profit Margin for a Supermarket?," CHRON, November 14, 2018, accessed July 27, 2023, https://smallbusiness.chron.com/profit-margin-supermarket-22467.html.

FIGURE 4: AVERAGE NET INCOME OF FOOD RETAILERS, 2012 TO 2022



Sources and Notes:
Food Retailing Industry Speaks, p 72.

Below, we illustrate the impact of the Final Rule on the net income for a typical store. For these calculations, we rely on sales and business-as-usual expenses reported by FMI. Consistent with our discussions above, we make the following assumptions to calculate the impact of the Proposed Rule on net income:

- The incremental capital cost of a transcritical CO_2 system is $1.1 million for an average-sized store.
- We assume that this incremental capital cost is financed by a loan with a 5.96% annual financing rate, with monthly payments spread over 15 years.
- Based on discussions with industry participants, we assume that approximately one-third of a store's utility costs are associated with refrigeration and that these costs increase by 20% for a transcritical CO_2 system, especially in less viable areas. These incremental costs reflect both electricity and water usage.

- Stores pass on 60% of the increase in utility costs to consumers.
- Owing to a lack of specific information, we do not consider any potential changes in maintenance or refrigerant costs.

Given these inputs, we calculate net income for the average store in 2024 and the net income that would prevail subject to the additional compliance costs under the Final Rule.

In Table 1 below, we find that the average store has a net income of approximately $500,000 in 2024. That net income would be reduced by about $115,000 per year if compliance with the Final Rule is required, a decrease of 22%. The smallest retailers are impacted the most on a percentage basis; their net incomes fall by 33%.

TABLE 1: IMPACT OF TRANSCRITICAL CO_2 SYSTEM COSTS ON NET INCOME

Category		All Retailers	Number of stores operated 1-10	11-100	>100
Annual Sales per store	[1]	$ 32,405,776	$ 20,646,548	$ 31,659,680	$ 32,607,068
Expenses excluding utilities	[2]	$ (31,530,820)	$ (20,171,677)	$ (30,868,188)	$ (31,433,214)
Utilities	[3]	$ (356,464)	$ (247,759)	$ (379,916)	$ (326,071)
Increase in energy costs for compliant systems	[4]	$ (23,764)	$ (16,517)	$ (25,328)	$ (21,738)
Amortized Compliance Capital Cost for given year	[5]	$ (105,975)	$ (68,391)	$ (101,442)	$ (106,854)
Pass-through of energy costs to consumers	[6]	$ 14,259	$ 9,910	$ 15,197	$ 13,043
Annual profit per store	[7]	$ 518,492	$ 227,112	$ 411,576	$ 847,784
Impact of the Proposed Rule on Profits	[8]	$ (115,481)	$ (74,998)	$ (111,573)	$ (115,550)
Annual profit per store after proposed rule	[9]	$ 403,012	$ 152,114	$ 300,003	$ 732,234

Sources and Notes:
Figures in parentheses indicate negative values (*i.e.,* costs).
[1], [2], [3]: Figures from Food Retailing Industry Speaks 2024 report, pages 116, 96, and 97.
[4]: [3] x (1/3) x (1/5). Assumes that refrigeration is 1/3 of utilities expenses and that these costs increase by 20% for compliant systems based on interviews with FMI members.
[5]: Assumes a 30% increase in capital costs for a compliant system relative to a baseline cost of $3.6 million for a 50,000 sq. foot store financed with a 15 year amortized monthly payment at a 5.96% interest rate.
[6]: [4] x 0.6. This assumes that 60% of the increase in utility costs is passed on to the consumer.
[7]: From Food Retailing Industry Speaks 2024.
[8]: [6] + [5] + [4]
[9]: [7] + [8]

Industry members are not anticipating more favorable profitability in the near-term. According to FMI's annual report, 72% of retailers expect their operating costs to increase this year and only 13% expect their profits to increase.[22] They continue to confront the impacts of inflation on their businesses, with 62% of retailers expecting inflation to put pressure on their margins.[23]

[22] The Food Retailing Industry Speaks, p. 83.

[23] The Food Retailing Industry Speaks, p. 83.

Given these headwinds, 23% of retailers expect more brick-and-mortar stores to close.[24] As it stands, 58% of retailers indicate that federal government regulations are negatively affecting their businesses, with 35% expecting regulatory costs to increase.[25]

Our analysis indicates that transcritical CO_2 systems would require larger capital investments that reduce store profitability at current prices. The European example indicates that much of the implementation of CO_2-based systems has been in Germany, where the government provides subsidies such that investment costs for HFC systems exceed those of CO_2-based systems.[26] Such financial inducements would be unnecessary if, as the EPA claims, transitioning to CO_2-based systems would reduce costs. As we discuss in Section IV, these costs can be mitigated by pursuing a market-based approach.

D. Due to Low Industry Margins, Higher Capital Costs May Reduce the Number of Grocery Stores

The analysis above indicates that, while the profit of the example store would fall, it would remain profitable. While this may hold for the typical store, some will likely no longer be profitable if compliance is required, pushing them out of business.[27] Others may not be sufficiently profitable to obtain a loan to finance upfront capital expenditures, leading them to limit the selection of refrigerated food that they offer. Even companies that could finance the project may decide that the return to that investment would be too low to justify the expense, leading to store closures or canceled openings.

These hardships are especially likely for small, local businesses as well as regional chains. Small businesses have lower annual profits, reducing their ability to finance capital investments and are less sophisticated than larger businesses that have dedicated planning and compliance

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[24] The Food Retailing Industry Speaks, p. 83.

[25] The Food Retailing Industry Speaks, p. 78 and p. 83.

[26] "Natural Refrigerants: State of the Industry," ATMO, 2022, p. 41, https://atmosphere.cool/marketreport-2022/.

[27] This result is consistent with the academic literature. Millimet et al. find that an increase in environmental standards discourages new firms from entering the market, induces existing firms to exit the market, and increases market concentration. See, Millimet et al., "Environmental Regulation and Economic Activity: Influence on Market Structure," *Annual Review of Resource Economics* 1 (2009): 99-117, https://www.jstor.org/stable/43202487. Li and Wang find that this pattern holds for firms in China. They use corporate registration information for all firms in 35 industries from 1991 to 2010 and show that environmental regulations deter firm entry and increase firm exit. See, Shuo Li and Min Wang, "Environmental Regulation and Firms' Extensive Margin Decisions An Evaluation of Environmental Regulation in China," JSTOR (October 2022): 1-39, https://www.jstor.org/stable/resrep46950.

teams. Smaller firms have less access to capital, making financing more expensive and expansions more difficult. They have fewer stores and less opportunity to "learn by doing" as well as smaller technical staffs. A study of the European experience in phasing out HFCs reports that "many smaller retailers have little technical capacity and are only taking first steps."[28] For this reason, the report recommends that governments "[f]inancially support smaller retailers to transition away from HFCs, particularly with respect to costs for new equipment."[29]

Medium-sized, regional companies may have corporate teams that can assist individual store managers with planning and compliance. However, these companies have been most susceptible to cost pressures from large national big box chains, including superstore footprints from Walmart and Target, as well as from cost-conscious options like Dollar General. Because of this competition, their margins have also been squeezed, reducing profits available to fund capital investments.[30]

According to FMI's annual industry report, many grocery stores are currently planning to reduce store area devoted to products that require refrigeration. Table 2 below indicates that 22% of stores intend to reduce area for the fresh meat department and 14% for the fresh seafood department; 23% plan to reduce the area devoted to frozen foods. This is a reversal from the prior year: grocers expected to increase space devoted to these categories on net.[31] This change may be due to the passage of the Final Rule.

Because of the capital investments required, the Final Rule will render some stores no longer profitable, leading to their closure. Stores may also reduce the number of linear feet devoted to products requiring refrigeration to control costs or avoid replacing outdated or failing equipment to avoid updating other refrigerated areas with working equipment.

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[28] "Chilling Facts VII: Are Europe's Supermarkets Ready to Quit HFCs?," EIA, June 2017, p. 12, https://eia-international.org/wp-content/uploads/Chilling-Facts-VII-FINAL-1.pdf, ("Chilling Facts VII").

[29] Chilling Facts VII, p. 22.

[30] Richard Volpe & Michael A. Boland, "The Economic Impacts of Walmart Supercenters," Annual Review of Resource Economics, October 2022. Accessed at: https://www.annualreviews.org/doi/abs/10.1146/annurev-resource-111820-032827.

[31] "The Food Retailing Industry Speaks," FMI, 2023, ("The Food Retailing Industry Speaks 2023"), Table 7.

TABLE 2: EXPECTED CHANGES IN AREA DEVOTED TO DEPARTMENTS REQUIRING REFRIGERATION

Item	All Retailers n=67-70		Number of Stores Operated 1-10 n=30-31		11-100 n=17-18		>100 n=20-21	
	↓	↑	↓	↑	↓	↑	↓	↑
Fresh meat	22%	9%	26%	6%	12%	18%	24%	5%
Fresh seafood	14%	6%	20%	7%	12%	6%	10%	5%
Frozen	23%	6%	29%	3%	6%	12%	24%	5%
Dairy	14%	3%	13%	0%	12%	6%	14%	5%
Alcoholic beverages	31%	1%	27%	3%	31%	0%	40%	0%
Fresh-prepared grab-and-go selection	79%	1%	77%	0%	88%	0%	71%	5%
Fresh produce	44%	0%	48%	0%	41%	0%	38%	0%

Sources and Notes:
The Food Retailing Industry Speaks, Table 7.

III. Higher Industry Costs Have Important Social Implications

Independent of the EPA's proposal, it has been widely reported that grocery prices have experienced high levels of inflation over the past few years. Because a large share of operating costs in the grocery industry is typically passed on to consumers, the Final Rule may extend these price trends. Consumers may also be impacted by store closures or reduced selection; this may be particularly likely in areas with limited access to fresh groceries, exacerbating the issue of "food deserts." These higher costs arise from increased energy use and higher system leakage, which also undercut the environmental benefits claimed by the EPA.

A. Groceries Have Experienced High Levels of Inflation

Food prices have increased substantially over the past several years. Table 3 below shows inflation overall and for food at home from the passage of the AIM Act to present (April 2025) and for a period of equal length prior to the passage of the AIM Act. Since passage, the price level of food increased by nearly 25%. This is nearly three times the inflation rate that prevailed prior to the AIM Act's passage. Figure 5 shows the year-over-year inflation rate for various categories of at-home food in 2022, all of which were above their historical averages. When considering a typical household, expenditures on food at home increased from about $6,230 in 2020 to $7,450 in 2024, an increase of over $1,200 per household.[32]

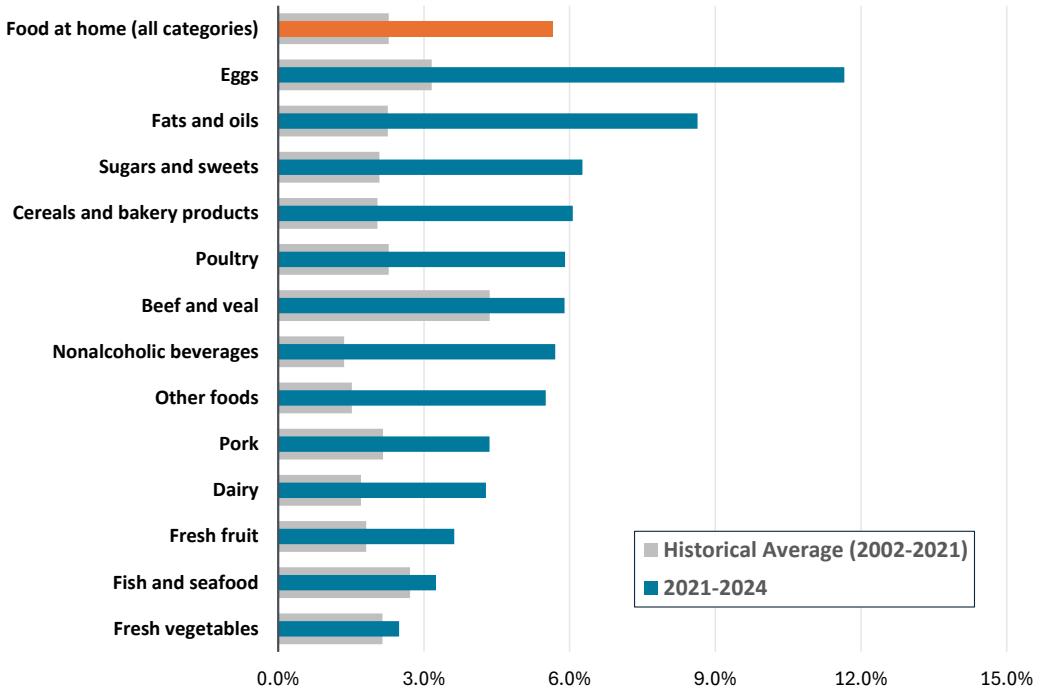
[32] "Food Expenditure Series," USDA, https://www.ers.usda.gov/data-products/food-expenditure-series/.

TABLE 3: INFLATION RATES

Period	Total Inflation	
	Overall	Food
AIM Act-April 2025 (52 months)	22.0%	24.7%
September 2025-AIM Act (52 months)	8.7%	8.9%

Sources and Notes:
Overall index includes all items in U.S city average. *See,* "CUSR0000SA0," BLS, https://data.bls.gov/timeseries/CUSR0000SA0. Food index includes food in U.S city average. *See,* "CUUR0000SAF1," BLS, https://data.bls.gov/timeseries/CUUR0000SAF1. The AIM Act was signed into effect on December 27, 2020. CPI data is monthly, as such CPI from January 2021 is used to determine inflation as of the AIM Act's passage. See https://www.epa.gov/climate-hfcs-reduction/background-hfcs-and-aim-act#AIM-Act

FIGURE 5: PRICE CHANGES FOR CPI FOOD AT HOME CATEGORIES, 2021-2022



Sources and Notes:
USDA, Economic Research Service using data from U.S. Depratment of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, https://public.tableau.com/app/profile/economic.research.service/viz/ACloserLookatRetailFoodSpendingandPriceEnvironment/FPEStory

B. The Proposed Rule Will Increase the Relative Price of Refrigerated Foods, Pushing Consumers Toward Less Healthy Options

In our discussion above, we cited industry case studies demonstrating that transcritical CO_2 systems use at least 5% and in many parts of the country closer to 20% more energy than comparable HFC systems. In addition to generating unintended negative environmental outcomes, this additional energy use leads to higher costs. These costs will likely be passed on to consumers.

Cost pass-through describes the degree to which a change in a firm's input costs lead to changes in the prices that the firm charges to consumers.[33] Pass-through in the grocery industry depends on several factors, including market competition, product differentiation, the price sensitivity of consumers, and the nature of the cost increase. Overall, because the grocery industry is competitive with low margins, we expect most increases in operating costs to be passed on to consumers.

Indeed, the academic literature confirms this expectation. Peltzman (2000) finds that 20% of cost increases are passed on to grocery consumers within the first month after the increase and over 50% of the increase is passed on after five months.[34] Besanko, Dubé, and Gupta (2005) study the pass-through behavior of a major supermarket chain covering 78 products across 11 categories and find that, while pass-through rates vary substantially across products and categories, on average they exceed 60%.[35] Evidence from the impact of a soda tax in the city of Philadelphia indicates that costs are passed through at an average rate of 97%.[36] These studies confirm that most of the increases in energy, refrigerant, and other operating costs are likely to be passed on to consumers.

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[33] Chris Walters et al., "Cost Pass-Through: Theory, Measurement, and Potential Policy Implications, A Report prepared for the Office of Fair Trading," *RBB Economics* (2014): p. 1-209, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/320912/Cost_Pass-Through_Report.pdf.

[34] Sam Peltzman, "Prices rise faster than they fall," *Journal of political economy* 108(3) (2000): p. 466-502, https://www.jstor.org/stable/10.1086/262126.

[35] David Besanko, Jean-Pierre Dubé, and Sachin Gupta, "Own-brand and cross-brand retail pass-through," *Marketing Science* 24(1) (2005): 123-137, https://www.jstor.org/stable/40056943.

[36] Stephan Seiler, Anna Tuchman, and Song Yao, "The impact of soda taxes: Pass-through, tax avoidance, and nutritional effects," *Journal of Marketing Research* 58(1) (2021): p. 22-49, https://doi.org/10.1177/0022243720969401.

Higher refrigeration costs are not likely to be spread equally across all the products in the store, however; instead, products requiring refrigeration (that is, the products inducing the increased costs) are the ones most likely to be impacted by the price increases. The products in the store that require refrigeration include frozen foods, meats, seafood, dairy products, and some fresh produce. These categories are colloquially described to be the "perimeter" of the store, whereas non-refrigerated goods occupy the interior of the store. Hence, the refrigerated "perimeter" products will have larger price increases and become relatively more expensive than products in the interior.

Because of these perimeter price increases, consumers will be incentivized to shop more from the interior. This has important health implications, as items from the perimeter tend to be healthier than those from the interior.[37] In particular, they are more likely to be "whole" foods, rather than processed foods. Non-refrigerated goods tend to contain additives or chemical preservatives that allow food to last longer and be shelf stable that may also impact health.[38] Therefore, the Final Rule may have an unintended negative impact on the health of consumers.

C. Access to Grocery Stores Has Important Social Implications

The United States Department of Agriculture ("USDA") formalizes the concept of "food deserts" as areas where a significant number of residents have *both* low incomes and limited access to supermarkets or large grocery stores.[39] These areas often lack affordable, fresh, and healthy food options. According to the USDA's Food Access Research Atlas, approximately 39.1 million people, or 12.7% of the US population live in a Low Income and Low Access ("LILA") Census tract as of 2015.[40]

Areas with higher levels of poverty are more likely to be food deserts, but the relevance of other factors, such as vehicle availability and the use of public transportation, differs between

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[37] "Grocery Store Tour: Shopping the Perimeter," Mayo Clinic Health system, March 23, 2018, accessed July 27, 2023, https://www.mayoclinichealthsystem.org/hometown-health/speaking-of-health/grocery-store-tour-shopping-the-perimeter ("Grocery Store Tour: Shopping the Perimeter").

[38] Grocery Store Tour: Shopping the Perimeter.

[39] "State-Level Estimates of Low Income and Low Access Populations," USDA, https://www.ers.usda.gov/data-products/food-access-research-atlas/state-level-estimates-of-low-income-and-low-access-populations/.

[40] Alana Rhone et al., "Low-Income and Low-Foodstore-Access Census Tracts, 2010–2019," USDA Economic Research Service, June 2022, Table 5, https://ers.usda.gov/sites/default/files/_laserfiche/publications/104158/EIB-236.pdf?v=35588

urban and rural areas. Multivariate analysis techniques conducted by the USDA show that measures of income inequality and racial segregation were important predictors of low access in urban core areas, while the most important factor in rural areas was lack of transportation infrastructure.[41] Overall, however, areas with higher poverty rates are more likely to be food deserts regardless of rural or urban designation.[42]

The map in Figure 6 below shows that food deserts (that is, LILA Census tracts) are found in every state, with larger concentrations in the southern states. As we discussed in Section II.B, the EPA recognizes that transcritical CO_2 systems are less viable in hot and humid regions, which includes much of the southern US. This region also has the largest number of Americans living in food deserts. Texas is the state with the highest absolute count of residents living in a LILA census tract, with 5 million people or 20% of its population. The two states with the highest shares of their populations living in food deserts are Mississippi (30%) and New Mexico (29%).[43] If grocery stores are required to comply with the Final Rule in these less viable areas, this policy may exacerbate the already high incidence of low access areas in this region.

Stores in these areas may be particularly susceptible to costs arising from the Final Rule. First, residents of these areas tend to be more price sensitive and more open to shopping for groceries at big box retailers and discount chains. This price sensitivity limits the ability of stores to pass on cost increases. Accordingly, stores in these regions may be more likely to fall below breakeven profitability and, ultimately, close. This would further reduce food access for vulnerable populations.

Second, these areas tend to be more rural, which increases operational costs. Stores in these areas are further from distribution centers and from corporate staff who travel from store to store. Rural areas also have fewer refrigeration technicians. According to Bureau of Labor Statistics data, as of 2024 urban areas have roughly 1.16 HVAC employee per 1,000 residents, whereas rural areas have 0.86—that is, 25% fewer.[44] Furthermore, there may be less technician

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41 "Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences—Report to Congress," USDA Economic Research Service, June 2009, https://www.ers.usda.gov/webdocs/publications/42711/12716_ap036_1_.pdf.

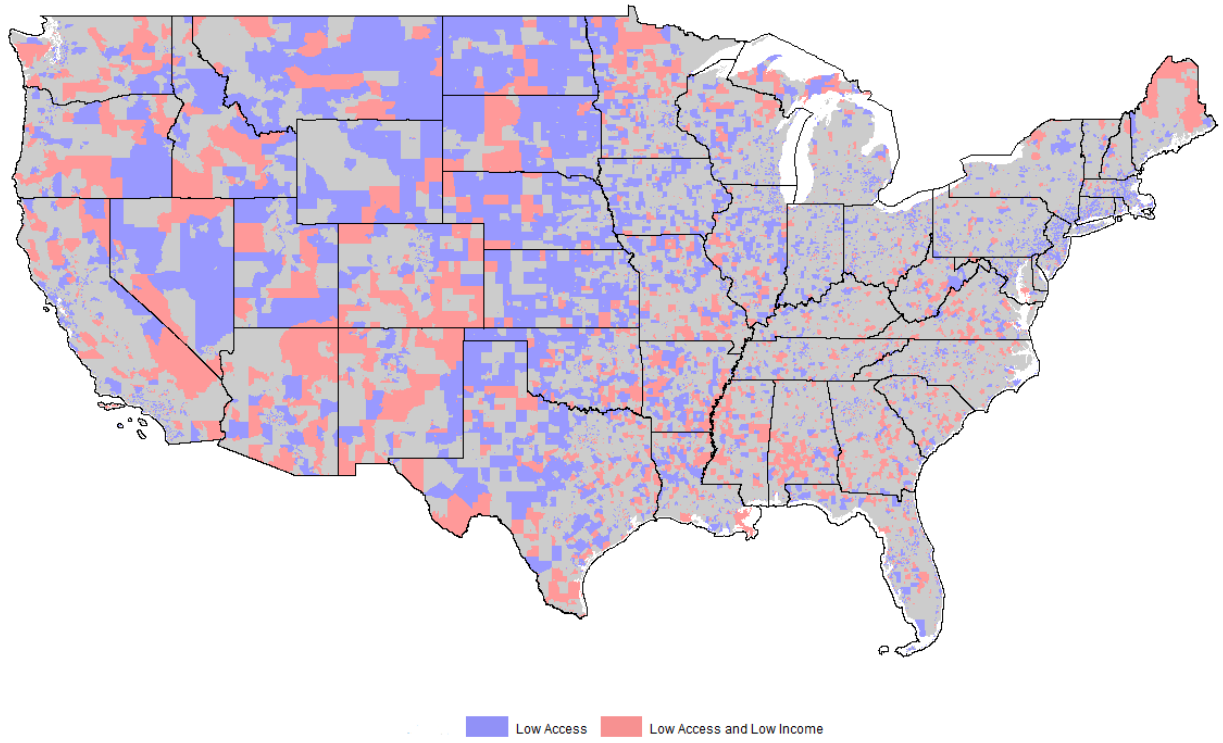
42 Paula Dutko, Michele Ver Ploeg and Tracey Farrigan, "Characteristics and Influential Factors of Food Deserts," USDA Economic Research Service, August 2012, https://www.ers.usda.gov/webdocs/publications/45014/30940_err140.pdf.

43 "State-Level Estimates of Low Income and Low Access Populations," USDA, https://www.ers.usda.gov/data-products/food-access-research-atlas/state-level-estimates-of-low-income-and-low-access-populations/.

44 "Occupational Employment and Wage Statistics: Metropolitan and nonmetropolitan area," May 2014 – May 2024, https://www.bls.gov/oes/tables.htm. Note: we consider HVAC workers under the occupational code "49-9021": "Heating, Air Conditioning, and Refrigeration Mechanics and Installers."

training available in rural areas, further limiting the number of technicians capable of servicing newer systems. Overall, the lack of qualified technicians, in both urban and rural areas, increases labor costs and store downtime.

FIGURE 6: LOW INCOME AND LOW ACCESS CENSUS TRACTS



Source: USDA Food Access Research Atlas, https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/. We use the variable LA1and10 which is measured at 1 mile for urban areas and 10 miles for rural areas.

Additionally, some studies indicate that white neighborhoods contain an average of four times as many supermarkets as predominantly black ones do and that grocery stores in black communities are often smaller with a selection that is more limited.[45] Because the Final Rule will increase the fixed costs of building and expanding grocery stores, this could exacerbate the differential in store density and selection products available in predominantly white versus predominantly black neighborhoods.

[45] Kimberly Morland et al., "Neighborhood characteristics associated with the location of food stores and food service places," *American Journal of Preventive Medicine* 22(1) (January 2002): p. 23-29, http://www.ncbi.nlm.nih.gov/pubmed/11777675.

D. Higher Energy Use and Higher Leakage Offset Some GHG Reduction Benefits

As we have discussed, transcritical CO_2 systems will likely use more energy and water resources than HFC systems, thereby offsetting some of the environmental benefits from relying on a lower GWP refrigerant. Based on discussions with industry participants, we understand that higher leak rates for transcritical CO_2 systems relative to traditional HFC systems further reduce the environmental benefits.[46] This result runs counter to the EPA's assumption of lower leak rates for these systems.

These higher leak rates are largely due to the relatively high-pressure nature of CO_2-based systems, which cause any leaks to vent much more refrigerant than lower pressure HFC systems. Additionally, CO_2 systems require safety relief valves that are much more likely to vent in the event of a system fault. Lastly, these relief vents often develop dry ice buildup, which prevents the valve from fully reseating; this can cause the relief vent to remain open until nearly all the CO_2 refrigerant has been released.

The climate benefits of the Final Rule will be reduced by the unintended impacts of higher energy use and higher leak rates. Furthermore, as we mentioned above, transcritical CO_2 systems with adiabatic gas coolers also consume substantial amounts of water, another unintended environmental cost. These impacts were not considered by the EPA in its assessment, leading to overstated benefits attributed to the Final Rule.

IV. An Extended Compliance Timeline Would Leverage Market-Based Efficiencies

The transition to compliant systems can only occur if the necessary equipment is available in sufficient quantities and is approved for use in grocery stores. It also requires a sufficient number of trained technicians to install and maintain these systems. Our interviews revealed

[46] If stores close in response to the Final Rule (or plans for new stores are scrapped), this can cause additional emissions increases. Not only would consumers have to travel further to shop (their transportation generating emissions), research by Dean (2020) finds that reductions in the number of grocery stores in an area can lead to additional food waste. Food waste contributes substantially to GHG emissions; emissions arising from food waste is equivalent to that of all road miles driven. Hence, the Final Rule can have a secondary unintended impact of increasing food waste and its associated emissions. See, James Dean, "Better Access to Groceries Could Reduce Food Waste, Emissions," January 31, 2020, accessed May 16, 2023, https://news.cornell.edu/stories/2020/01/better-access-groceries-could-reduce-food-waste-emissions.

that increasing HFC prices are already encouraging installation of transcritical CO_2 systems in new stores where these systems are most viable. This early adoption can spur improvements in the manufacturing process as well as further innovation, reducing system costs and initiating a virtuous circle of uptake. This market-driven approach uses the most cost effective projects to lead the technology transition.

More expansive requirements, particularly those covering less viable areas or modifications of existing stores, will substantially increase the costs of the Final Rule. Mandatory widespread adoption would put high pressure on labor markets and on supply chains, raising costs for all projects.

A. Ratcheting Caps on HFC Production Will Induce New Stores to Shift Away From HFCs

As we discussed in Section II.B, HFC prices, notably for R-404A, have increased substantially. This is largely due to ratcheting restrictions on HFC production that have been instituted in both the US and in Europe.[47] These price increases are likely to persist, incentivizing the industry to transition away from HFC-based systems. Crucially, the price mechanism encourages stores with the lowest costs of transitioning to do so first, thereby maximizing the net benefits of the rule.

There are at least three factors that we expect—and observe—to influence the propensity of stores to transition to alternative refrigerants:

- First, companies will focus on developing new stores around alternative refrigerants rather than on retrofitting existing stores. We discuss the particularly high costs of retrofitting existing stores below.
- Second, stores in more favorable climates are more likely to transition earlier. Hannaford, a chain based in northern New England, considers transcritical CO_2 "the new standard" for its new stores.[48] Among the industry representatives who we spoke with, the ones most

[47] For US, see a related rule from the EPA, "Phasedown of Hydrofluorocarbons: Allowance Allocation Methodology for 2024 and Later Years", Federal Register, https://www.federalregister.gov/documents/2023/07/20/2023-14312/phasedown-of-hydrofluorocarbons-allowance-allocation-methodology-for-2024-and-later-years; For Europe, see European Commission, "EU legislation to control F-gases," 2014, https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/eu-legislation-control-f-gases_en.

[48] Transcritical Update: Hannaford Supermarkets.

optimistic about transcritical CO_2 were ones who have opened stores in states along the Canadian border.[49]

- Third, larger public companies with more ready access to capital and potentially higher margins are more capable of undertaking these investments. For example, Target announced plans to scale transcritical CO_2 systems chain-wide by 2040.[50] Walmart has committed to using "ultra-low GWP" systems "in new construction where commercially available."[51] As of this year, Whole Foods has pledged that all new stores would use natural refrigerants; [52] Aldi has pledged use natural refrigerants in all its stores by 2035.[53]

The caps on HFC production already provide substantial incentives to transition to alternative refrigerants. Notably, the price mechanism encourages the most efficient transitions to happen first. These early adopters help fund the learning-by-doing process that lowers manufacturing costs as well as the development of more favorable technologies. These industrial improvements enable more projects to pass a cost-benefit calculation in the future. The ratcheting of the caps also encourages a staggered transition, further controlling costs.

B. Manufacturing Costs Are Likely to Fall and Efficiency to Rise in the Future

One reason that the price incentive created by ratcheting HFC production limits is particularly cost-effective is that the new technologies will become less expensive as they are developed over time. This is a common phenomenon in manufacturing called "learning by doing." A particularly notable illustration is the solar industry. In the span of a decade, solar costs have fallen by a factor of 5, reaching prices that are competitive with fossil fuels, as shown in Figure

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[49] Even these industry representatives were concerned about the costs associated with retrofitting stores with transcritical CO_2 systems, however.

[50] "Target Tests First Net Zero Energy Store," Target, March 17, 2022, accessed July 27, 2023, https://corporate.target.com/press/releases/2022/03/target-tests-first-net-zero-energy-store.

[51] "Climate Change," Walmart, May 19, 2023, accessed July 27, 2023, https://corporate.target.com/press/releases/2022/03/target-tests-first-net-zero-energy-store.

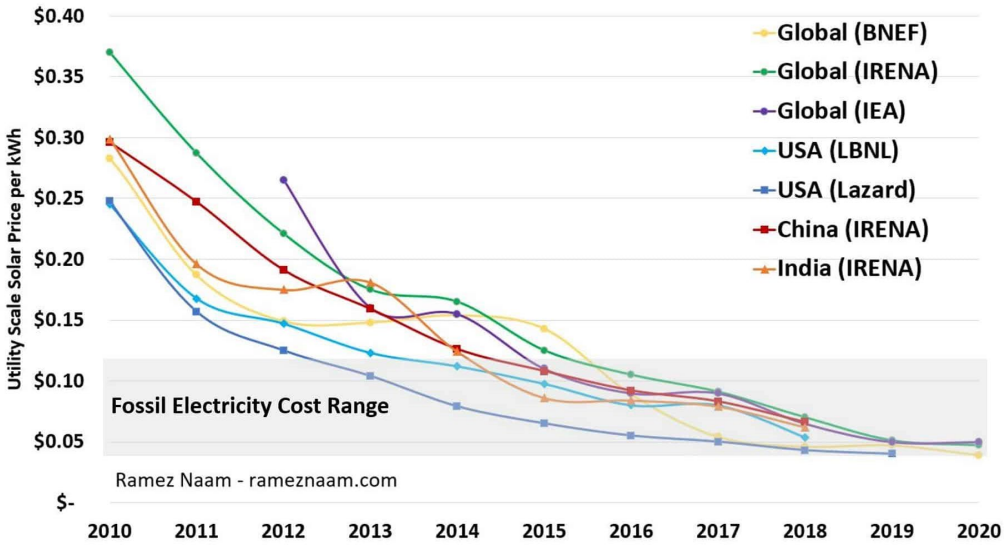
[52] See "Kroger's move to climate-friendly refrigeration will benefit environment, brand | Opinion," Cincinnati.com, accessed at https://eu.cincinnati.com/story/opinion/contributors/2024/07/31/kroger-adopts-natural-refrigerant-technology-to-reduce-carbon-emissions/74427561007/

[53] *See* "ALDI becomes first U.S. food retailer to commit to natural refrigerants across all stores," Climate Friendly Supermarkets, retrieved from https://www.climatefriendlysupermarkets.org/media/aldi-becomes-first-u-s-food-retailer-to-commit-to-natural-refrigerants-across-all-stores.

7.[54] Falling costs have coincided with (and contributed to) increased use and production of solar cells; Figure 8 shows exponential growth in solar production. These improvements in manufacturing processes have made solar a competitive energy alternative in many more regions and applications.

These patterns are likely to arise for alternative refrigeration systems. As a promising piece of evidence, a study of HFC transitions in Europe describes notable progress that has been made for smaller systems: new systems that are in development may be more energy efficient than HFC systems with a smaller size.[55] As another example, a case study comparing the performance of transcritical CO_2 and A2L systems in Britain found that the A2L system reduced energy use by 34%, reduced leakage, and reduced maintenance costs.[56] We understand that these systems are not available for widespread use in the US at this point, in part due to the need for updates to building codes and other regulations; however, in the future these systems will provide a more viable alternative for many stores.

FIGURE 7: SOLAR COSTS, 2010-2020



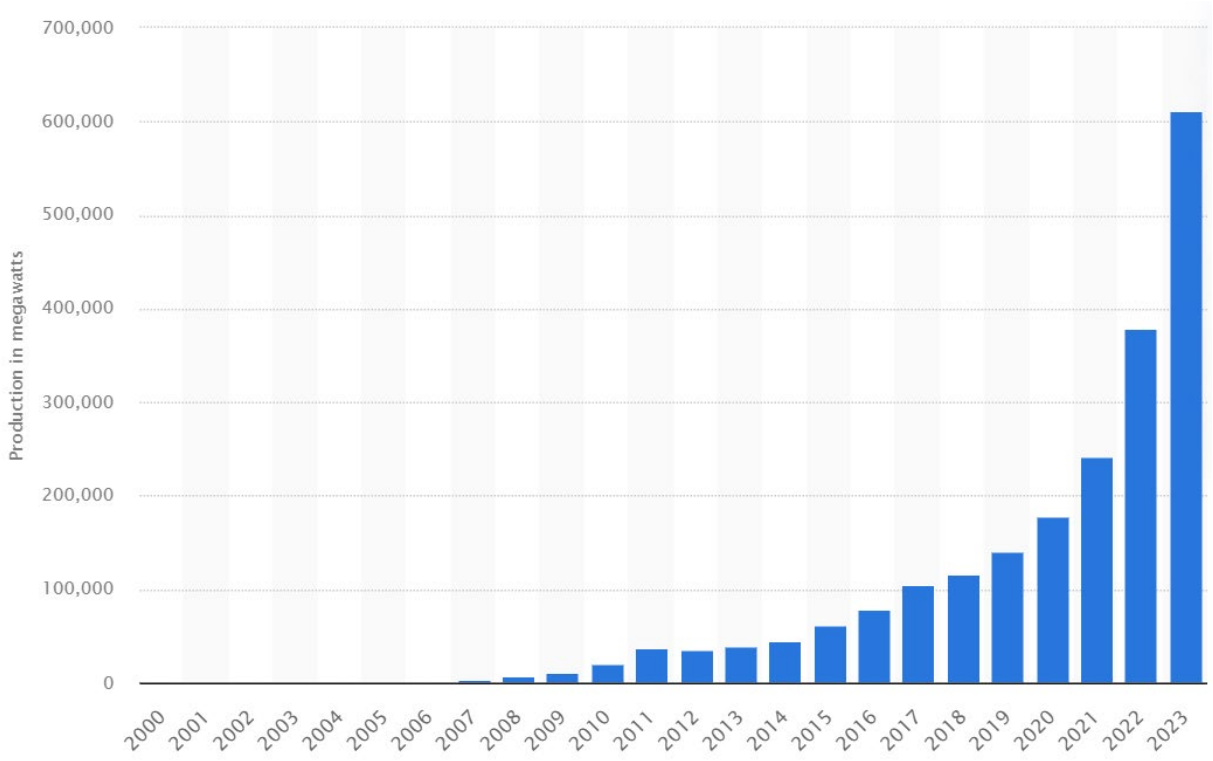
Sources and Notes:
"Solar's Future is Insanely Cheap," Ramez Naam, 2020, https://rameznaam.com/2020/05/14/solars-future-is-insanely-cheap-2020/.

[54] "Solar's Future is Insanely Cheap," Ramez Naam, 2020, https://rameznaam.com/2020/05/14/solars-future-is-insanely-cheap-2020/.

[55] Chilling Facts VII, p. 20.

[56] "ASDA and A2L: How HFOs are helping retailers get more, for less," Opteon, p. 2, https://www.opteon.com/en/-/media/files/opteon/case-studies/opteon-asda-casestudy.pdf?la=en&rev=3709edb1eee141c39f9dee2137fdbeba.

FIGURE 8: SOLAR PRODUCTION, 2000-2023



Source and Notes: "Annual solar module production globally from 2000 to 2023", Statista, 2025, https://www.statista.com/statistics/668764/annual-solar-module-manufacturing-globally/

C. Implementation Is Constrained by the Availability of Equipment and Technicians

Compressed compliance timelines induce a burst of demand for machinery, parts, and labor; these bursts are accommodated through a combination of project delays and increases in costs. As discussed above, manufacturing output and competence will grow over time; today, companies would compete over relatively limited availability of equipment. Larger retailers will have more influence with suppliers, disadvantaging small- and medium-sized businesses.

Another key limitation to transitioning to compliant systems will be the number of technicians able to install and service these systems. Transcritical CO_2 systems are more complex than traditional HFC systems and require new training for technicians. The lack of qualified technicians has proven to be a bottleneck in Europe's transition to low GWP refrigerants.[57] A

[57] *See* "Supermarkets are tackling emissions from their freezer aisles," Trellis, retrieved from https://trellis.net/article/supermarkets-are-tackling-emissions-their-freezer-aisles/

more gradual transition would enhance workforce development opportunities, reducing the impact of labor shortages on costs and installation timelines.

Here, too, the solar energy industry provides instructive evidence. Several studies have found that, while the overall cost of solar has fallen as components become less expensive and the technology becomes more efficient, the rate of the cost decline has been slowed by increasing "soft costs," including labor for installation and permitting costs.[58] Programs to train more technicians and reductions in permitting requirements have been introduced to address these issues in the solar industry.

D. Converting Existing Stores Is Difficult to Justify At Current Costs

Across all our interviews with industry participants, there was unanimous agreement that converting existing stores from HFCs to a transcritical CO_2 system would be incredibly disruptive and expensive. Under normal business practices, remodels or replacements typically occur for only a portion of equipment at a given time. This is partly because different system components have different lifespans: cases last for roughly 10 to 15 years, while compressors and condensers can last from 20 to 30 years. Thus, while cases need to be replaced more frequently, the overall infrastructure of the system can remain intact. The smaller scale of these replacements reduces the disruptions experienced by consumers.

A typical project might be to remove and replace cases that have rusted. If this kind of project triggers requirements to transition to a low GWP system, the company would likely determine that it is not cost effective to replace the entire refrigeration system; instead, it would make do with the damaged cases or remove them and reduce the linear feet devoted to refrigerated goods. In fact, comparing industry reports from before and after finalization of the Technology Transition Rule, survey respondents switched from expecting to expand refrigerated sections to expecting to contract them.[59]

Another example project would be to replace cases with more modern, more energy efficient versions. Here, too, the project is unlikely to generate a sufficient return to justify replacing the

[58] Vignesh Ramasamy et al., "U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, with Minimum Sustainable Price Analysis: Q1 2022," National Renewable Energy Laboratory, https://www.nrel.gov/docs/fy22osti/83586.pdf.

[59] The Food Retailing Industry Speaks, Table 7; The Food Retailing Industry Speaks 2023, Table 7.

entire refrigeration system if required under the Final Rule. Instead, the store may enact half-measures, such as installing doors on cases. While these updates can improve the energy efficiency of the store, projects that would generate even larger energy savings would be forestalled due to the burdens of the rule.

While transitioning to an "ultra low" GWP alternative may not be cost effective for existing stores, retrofitting systems to use lower GWP HFC blends may provide a cost-effective middle ground. A study in Europe found that major grocers have reduced consumption of the highest GWP HFCs (HFC-404A and HFC-507/507A), but increased use of lower GWP HFCs (HFC-407A/407C/407F).[60] Several industry members who we spoke with indicated that they have retrofitted stores using HFC-448A/449 and that these conversions can reuse much of the existing system infrastructure. These substitutions indicate that cost-effective net reductions of GHG emissions for store conversions are possible by switching to intermediate HFCs rather than transitioning entirely away from HFCs. This is particularly the case if these alternative gases can be used in existing systems.

[60] Chilling Facts VII, p. 4.