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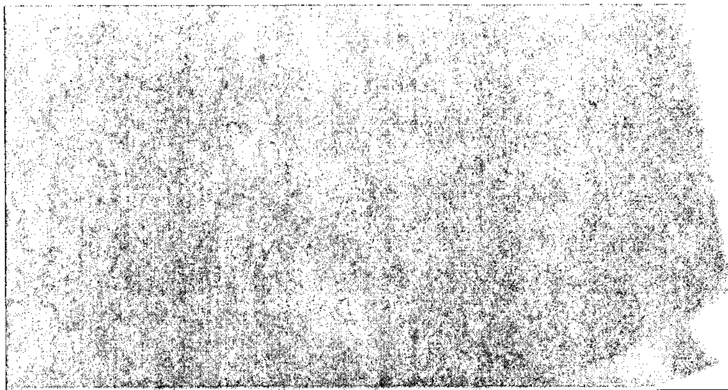

DeCO2ded – Understanding the ROI on CO_2 Refrigeration Systems

Determining ROI on a CO_2 System Requires a Number of Variables and Real-World Calculations

September 2019

DeCO2ded — Understanding ROI on CO_2 Refrigeration Systems

Background

There is probably no greater agent of change in today's retail food industry world than the impact of environmental regulatory actions on the usage of refrigerants. With CFCs and halons already phased out with the Montreal Protocol, HCFCs like R-22 with one foot already out the exit door, and the handwriting for the inevitable demise of HFCs on the wall, retailers are being forced to take action to remain compliant for the long term with their refrigeration systems.

The immediate question at hand for grocers and other affected commercial businesses is whether to retrofit or replace their existing refrigeration systems. How much will it cost to switch from a traditional HFC-based system to one using a 100% natural refrigerant like CO_2? The answer goes well beyond a simple dollars-and-cents calculation. A better question to ask is, "What's the total return on investment with a 100% CO_2 system?" Any cost/benefit analysis to justify the expenditure would certainly start with the initial system cost. However, a true, "big picture" assessment would have to include a number of other tangible and intangible factors — everything from system operational performance to the costs of electricity and refrigerant to regulatory compliance and more. Only by going to this length can grocers truly see whether an alternative refrigeration system, like CO2, will save them money, time, and perhaps most importantly, peace-of-mind delivered by "future-proofing" their business.

Determining ROI on a CO_2 refrigeration system requires considering the cost impact of associated variables, including but not limited to:

1. Refrigerant
2. Location
3. Energy
4. Equipment
5. System Installation

6. System Maintenance and Performance
7. Regulatory Impact

This paper will delve into each of these variables, offering real-world ROI calculations derived from CO_2 systems installed and currently operating in three U.S. supermarkets. But before we even begin looking at numbers, let's first summarize some of the key facts that address the basic question at hand, "Why even entertain the thought of a CO_2 refrigeration system?" At the core of the answer to that question are the favorable characteristics of a CO_2-based system that surface when comparing and contrasting CO_2 versus HFC systems. Among those key differences promoting CO_2 are:

- Natural (unlike other refrigerants, they are natural substances and not synthetic chemicals) and inexpensive, readily-available refrigerant
- Sustainable with low global warming potential (GWP) and no ozone depletion potential (ODP = 0) — can legally be vented to the atmosphere (nontoxic)
- Requires less refrigerant charge
- Cheaper to install — significantly smaller copper piping system — cost of materials involved is lower
- High quality heat reclaim opportunities
- Energy-efficient in most climates and quiet

Determining ROI on CO2 Applications

1. Refrigerant

Although some elements of CO_2 system ROI calculations are more complex due to their dependency on variables such as system baseline design, the same cannot be said for the savings involving the refrigerant itself. From the start-up date of a newly-installed CO_2 system, a supermarket immediately begins saving money on refrigerant charge cost. Here's a typical scenario of a store changing over from an HFC-based system to one employing CO_2:

Start-Up Refrigerant Scenario

- Required system start-up refrigerant charge = 2,000 pounds
- Cost of HFC-based refrigerant (e.g., R404A) @ $10.00 per pound
  - 2,000 pounds X $10.00 per pound = $20,000
- Cost of CO2-based refrigerant (e.g., R744) @ $1.00 per pound
  - 2,000 pounds X $1.00 per pound = $2,000
- **Savings Using CO_2 = $18,000**

Start-Up Refrigerant Scenario

In this actual, real-world example, a supermarket installed a CO2 booster system with a low-temperature refrigeration load of 200 MBTUH and a medium-temperature load of 650 MBTUH. The following chart shows the immediate benefits realized by the business:

ROI Summary	MT HFC DX LT HFC DX	Advansor CO_2 Booster	Difference	
Initial Refrigerant Cost	$17,500	$3,600	($13,900)	-79.4%
Annual Refrigerant Cost	$3,500	$720	($2,780)	-79.4%

2. Location

CO_2 Breakthrough — Sprouts Farmers Market and Hillphoenix Partner on Warm-Climate CO_2 System

A partnership between supermarket chain, Sprouts Farmers Market, and commercial refrigeration equipment provider, Hillphoenix, led to and industry breakthrough — the first warm-climate CO_2 Advansor transcritical booster system.

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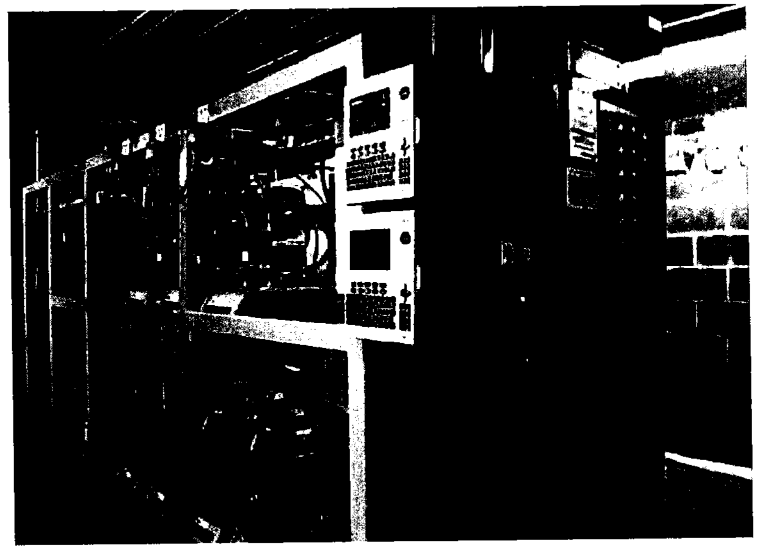

The HFC-free refrigeration system which was installed in a Sprouts store in Georgia in July 2014, overcame a long-standing technological barrier. For years, retail, commercial and industrial users of refrigeration systems understood that a CO_2-based system was the cleanest and most environmentally friendly HFC-free option. But questions lingered whether a CO_2-based, air-cooled system could operate efficiently in locations where outdoor ambient temperatures were above 80° F. This climate-driven limitation was dubbed the "CO_2 Equator", which referred to the generally accepted geographical limit for cost-effective deployment of CO_2 systems in food retail.

Key to this success at Sprouts was leveraging the efficiency improvements gained through the integration of technological innovations such as adiabatic gas coolers and parallel compression systems. The CO_2 system results achieved at the Sprouts metro Atlanta store demonstrated the feasibility of using such systems in warmer climates, thereby placing sustainable, alternative refrigeration within the reach of stores in almost any market.

The significance of this was not lost on the management of Sprouts. "Central to Sprouts' identity is a genuine commitment to responsible retailing," said Ted Frumkin, senior vice president of business development for Sprouts. "This innovative partnership with Hillphoenix helps Sprouts reduce our environmental impact, which we know is important to our customers and our team members."

Since the Sprouts installation in 2014, the integration of several key design material and process technology advances (e.g., gas ejector systems, high pressure sub-coolers, etc.) has led to solutions with lower cost that remove flash gas in hot climates and further improve the system's overall efficiency and performance. Collectively, this has driven the CO_2 Equator to near elimination.

3. Energy

Energy is a huge expense for supermarkets. A 50,000 sq. ft. store spends more than $200,000 annually on electricity — and half of that is spent on refrigeration, according to the U.S. Department of Energy.

In most cases, CO_2 can be more efficient, and therefore more cost-effective to operate, than traditional commercial refrigeration systems. Depending on a store's geographic location, source of power (e.g., utility power cost), and degree of implementation of technological advances, a supermarket can save on average from 5% to 18% on energy bills. There are a number of examples of retail food stores outperforming these results. One such New Jersey supermarket chain experienced well over 30% annualized energy savings when comparing their store having an Advansor CO_2 booster system against their other stores having traditional HFC-based systems.

The somewhat recent development and usage of transcritical rack controllers with their associated logic offer further optimization of compressor and overall system operation allowing additional reduction of overall energy cost.

4. Equipment

Specialized valves, steel piping, compressors and electronic controls used in a CO_2 booster system tend to drive up the cost of equipment when compared to their traditional HFC counterparts. But, as is true with any new, emerging technology — from manufacturing equipment to computers to smart phones — CO_2 equipment is following suit with the same pricing evolution based on economy of scale. Innovative technology is generally more expensive at its inception than what is already on the market, driven in large part by its new functionality and greater benefits. But as more and more consumers and businesses adopt it, competitive dynamics take over and the price falls. Such is the case currently with CO_2 technology.

Over 35,000 transcritical CO_2 refrigeration systems now operate in stores across the globe. Sales are ballooning as grocers look for ways to increase their sustainability and profitability and get ahead of coming regulatory changes before they are trapped. Research from market development firm, Shecco, indicates a robust growth in Europe with the number of CO_2 transcritical systems going from 140 in 2008 to 29,000 in May 2020. And that growth is accelerating fast as shown by an 81% increase alone from 2018 to 2020. Aligned with these statistics, Hillphoenix Advansor CO_2 system sales have increased over 500% since 2009.

Tallying the Return on a CO_2 Booster System — Equipment

The initial price tag for CO_2 refrigeration system equipment is currently higher than for a traditional HFC system. But countering that is the fact that CO2 offers a greater return on investment over time which more than mitigates the initial cost.

ROI Summary	MT HFC DX LT HFC DX	Advansor CO_2 Booster	Difference	
Equipment Costs	$870,600	$1,015,235	$144,635	16.6%

These numbers can vary based on system configuration and baseline design. Additionally, the numbers are continually moving based on the impact of regulatory actions which negatively affect the HFC systems. This dynamic serves to continuously diminish the difference between the HFC and CO_2 equipment costs.

5. System Installation

Electrical installation generally costs less with CO_2 than with traditional HFC systems. For example, in CO_2 systems, each case and walk-in uses a case controller. All the internal wiring — for lights, anti-sweats, fans, defrosters and sensors — is factory-wired to operate from the controller. So, a single-point electrical connection is all that's needed. A grocer can eliminate the cost of additional wiring and control boxes from the project's design and installation budget.

Refrigeration installation costs are consistently lower with CO_2. The CO_2 design requires smaller copper pipe sizes, which lowers material costs. And the smaller line sizes in a CO_2 system are easier to install, which lowers labor costs. The advancement of high-pressure copper versus stainless steel or welded pipe has helped lower high-side piping costs. C194 copper-iron alloy, with its high strength, resistance to softening during brazing, and superior corrosion resistance characteristics, permits tube wall reductions of nearly one-third with resultant cost savings and weight reduction.

Overall, grocers can expect savings on average of 12% to 18% on CO_2 installation, based on projects tracked by Hillphoenix, which has helped supermarkets install more than 300 CO_2 systems in North America alone since 2012.

Tallying the Return on a CO_2 Booster System — Installation

With CO_2, electrical and refrigeration installation costs are generally lower — driving favorable overall savings.

ROI Summary	MT HFC DX LT HFC DX	Advansor CO_2 Booster	Difference	
Refrigeration Install Cost	$300,988	$246,000	($54,988)	-18.3%
Electrical Install Cost	$126,700	$101,450	($25,250)	-19.9%

6. System Maintenance and Performance

The case controllers and electronic expansion valves in a CO_2 system control case temperature and superheat automatically. That provides optimal evaporator performance and energy use at all times as well as eliminating the need to do routine maintenance adjustments.

CO_2 case controllers regulate temperature better than traditional systems, improving the shelf life of foods stocked and merchandised in refrigerated cases. That gives grocers more time to make sales and adds to the cost savings by reducing product shrinkage.

With CO_2, you also get the added advantage of the inherently lower risk for the need for annual replacement refrigerant charge, manifesting in lower maintenance contract cost.

7. Regulatory Impact

At the moment, equipment for a 100% CO_2, HFC-free commercial refrigeration system has a higher upfront price tag than a traditional HFC system. But besides offering a superior payback, CO_2 presents grocers with an opportunity to "future-proof" a significant portion of their capex; save time and headaches going forward; and gain invaluable peace-of-mind. A 100% CO_2 system eliminates the need for refrigerant retrofits and the burden of complying with current and future regulations related to HFCs. You can sleep well at night — for many, many nights to come!

With 100% CO_2 refrigeration systems, stores operate more sustainably and environmentally responsible — and grocers can add that fact to their list of corporate social responsibility wins.

Adding It Up — A Closer Look at ROI on CO_2-Based Systems

A cost/benefit analysis using data from CO_2 commercial refrigeration systems currently operating in three typical U.S. supermarkets shows a positive return on investment across different project sizes. ROI can vary from immediate, upfront savings to a break-even point that occurs 10 years after installation. **Note that these charts do not reflect intangible benefits, such as future cost avoidance and reduced regulatory paperwork.**

Example A: Based on a low-temperature refrigeration load of 330 MBTUH and a medium-temperature load of 1050 MBTUH

ROI Summary	MT Glycol LT HFC DX	Advansor CO_2 Booster	Difference	
Equipment Costs	**$1,125,353**	**$1,246,939**	**$121,586**	**10.8%**
Initial refrigerant cost	$31,724	$1,980	$(29,744)	-93.8%
Refrigeration install cost	$557,375	$414,933	$(142,442)	-25.6%
Electrical install cost	$75,030	$98,850	$23,820	31.7%
Installation Costs	**$664,129**	**$515,763**	**$(148,366)**	**-22.3%**
Annual refrigerant cost	$4,160	$396	$(3,764)	-90.5%
Annual operating cost	$121,447	$108,622	$(12,825)	-10.6%
Annual Totals	**$125,607**	**$109,018**	**$(16,589)**	**-13.2%**

Equipment Cost Difference	**$121,586**
Installation Cost Savings	**$(148,366)**
Balance	**$(26,780)**
Annual Maintenance & Operating Cost Savings	**$(16,589)**
ROI in Years	**Savings starts at Install**

Example B: Based on a low-temperature refrigeration load of 250 MBTUH and a medium-temperature load of 750 MBTUH

ROI Summary	MT HFC DX LT HFC DX	Advansor CO_2 Booster	Difference	
Equipment Costs	**$826,570**	**$1,024,630**	**$198,060**	**24.0%**
Initial refrigerant cost	$20,800	$2,250	$(18,550)	-89.2%
Refrigeration install cost	$398,486	$298,000	$(100,486)	-25.2%
Electrical install cost	$277,388	$248,000	$(29,388)	-10.6%
Installation Costs	**$696,674**	**$548,250**	**$(148,424)**	**-21.3%**
Annual refrigerant cost	$3,188	$275	$(2,913)	-91.4%
Annual operating cost	$110,332	$93,477	$(16,855)	-15.3%
Annual Totals	**$113,520**	**$93,752**	**$(19,768)**	**-17.4%**

Equipment Cost Difference	**$198,060**
Installation Cost Savings	**$(148,424)**
Balance	**$49,636**
Annual Maintenance & Operating Cost Savings	**$(19,768)**
ROI in Years	**2.5 years**

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Example C: Based on a low-temperature refrigeration load of 200 MBTUH and a medium-temperature load of 650 MBTUH

ROI Summary	MT HFC DX LT HFC DX	Advansor CO_2 Booster	Difference	
Equipment Costs	**$870,600**	**$1,015,235**	**$144,635**	**16.6%**
Initial refrigerant cost	$10,500	$3,600	$(6,900)	-65.7%
Refrigeration install cost	$300,988	$246,000	$(54,988)	-18.3%
Electrical install cost	$126,700	$101,450	$(25,250)	-19.9%
Installation Costs	**$438,188**	**$351,050**	**$(87,138)**	**-19.9%**
Annual refrigerant cost	$2,100	$720	$(1,380)	-65.7%
Annual operating cost	$122,459	$113,500	$(8,959)	-7.3%
Annual Totals	**$124,559**	**$114,220**	**$(10,339)**	**-8.3%**

Equipment Cost Difference	**$144,635**
Installation Cost Savings	**$(87,138)**
Balance	**$57,497**
Annual Maintenance & Operating Cost Savings	**$(10,339)**
ROI in Years	**5.6 years**

Conclusion

A grocer who's considering retrofitting or replacing commercial refrigeration systems will gain a truer view of the costs and benefits of different systems by considering more than just initial price. Comparing the short- and long-term return on investment of traditional HFC systems vs. CO_2 systems offers a more thorough analysis. Determining ROI on commercial refrigeration systems requires considering variables such as the cost of refrigerant, location, energy, equipment, installation, maintenance and regulatory impact. CO_2 technology is advancing rapidly with constant innovations resulting in increased efficiency and system performance while reducing the costs involved. Understanding ROI allows a grocer to make strategic, forward-thinking decisions that not only meet today's challenges, but also help future-proof the business.

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About Hillphoenix

Hillphoenix branded products and services deliver advanced design and manufacturing of commercial refrigerated display cases and specialty products along with commercial and industrial refrigeration systems and integrated power distribution systems. Training, design, energy and aftermarket services are available through the Hillphoenix Learning and Design Centers and The AMS Group. For more information visit www.hillphoenix.com, or call 800-283-1109