

**Bennu Productions LLC**

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# **Opportunities for Decarbonization in Industrial Refrigeration**

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December 2022

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# What is Net Zero?



Net Zero

- The term **Net Zero** refers to the target of reducing the greenhouse gas emissions that cause global warming to zero, by balancing the amount released into the atmosphere from sources with the amount removed and stored by carbon sinks
- In accordance with the 2015 Paris Agreement, the world must reach Net Zero GHG emissions early in the second half of the present century. That will require the transformation of economies and societies alike
- Many countries and corporations are setting their aspirations to achieve net zero goals by 2050

# What is Decarbonization?



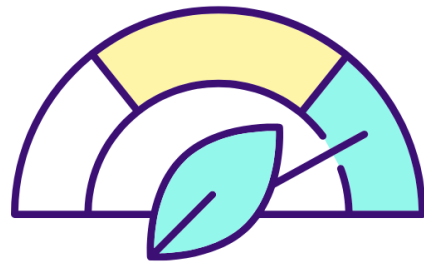
Decarbonization

**Decarbonizing** existing buildings means getting them completely off fossil fuels. Without burning fossil fuels onsite, most buildings will need to provide space and water heating using electricity instead— typically with heat pumps.

**Electrification:** Refers to using technologies such as vehicles or heat pumps that operate with electricity instead of burning fossil fuels such as oil, gas, and coal. Electricity generated through clean resources such as wind and solar power is considered a decarbonization strategy.

**U.S. Green Building Council** supports beneficial electrification, specifically with deep **energy efficiency** and peak management, as a core strategy for building **decarbonization**.

# What is Energy Efficiency?



Energy Efficiency

**Energy efficiency** is the use of less energy to perform the same task or produce the same result. Energy-efficient homes, buildings, and industries use less energy to heat, cool, and run appliances and electronics, and energy-efficient manufacturing facilities use less energy to produce goods.

**Energy efficiency** is one of the easiest and most cost-effective ways to combat climate change, reduce energy costs for consumers, and improve the competitiveness of U.S. businesses.

**Energy efficiency** is also a vital component in **achieving Net Zero emissions of carbon dioxide through decarbonization.**

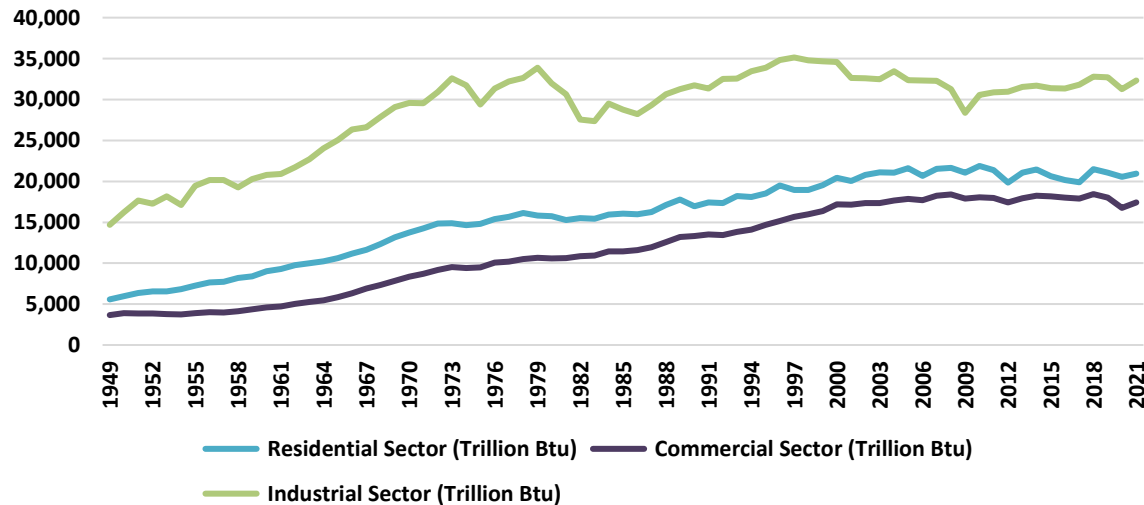
The Office of Energy Efficiency and Renewable Energy (EERE)

<https://www.energy.gov/eere/office-energy-efficiency-renewable-energy>

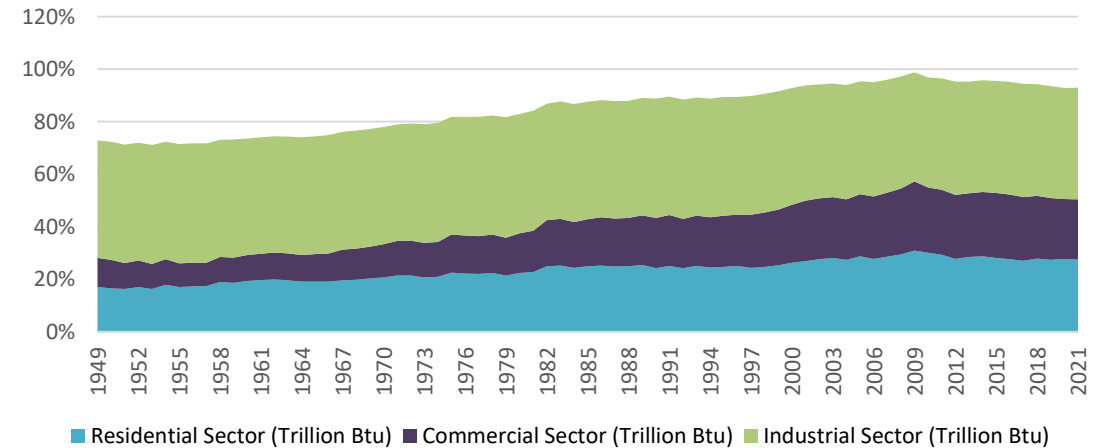
# Energy Consumption Comparison Residential, Commercial, and Industrial Sectors



**Table 2.1a Energy Consumption: Residential, Commercial, and Industrial Sectors Title**



**Energy Consumed by Residential, Commercial and Industrial Sectors - Participation%**



- Residential Sector: 23% in 1949 and 30% in 2021
- Commercial Sector: 15% in 1949 and 25% in 2021
- Industry Sector: 61% in 1949 and 45% in 2021

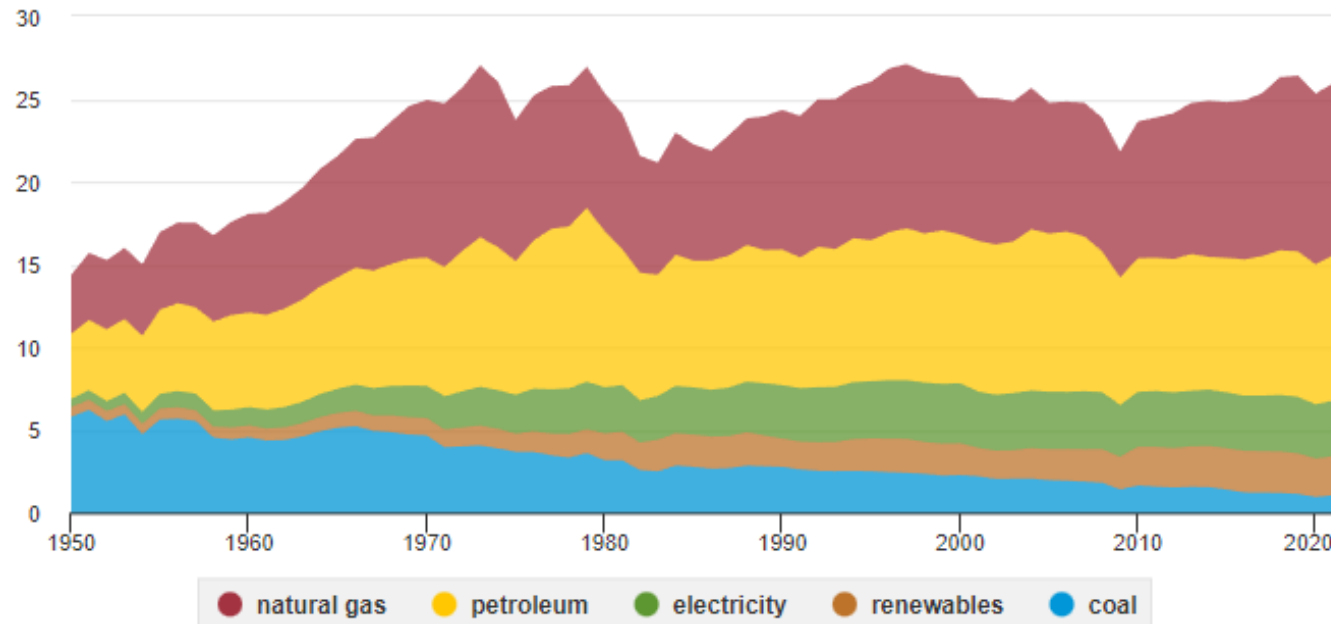
The industry is the bigger energy consumer sector in the USA.

# Energy Use by Source



## U.S. industrial sector energy use by source, 1950-2021

quadrillion British thermal units

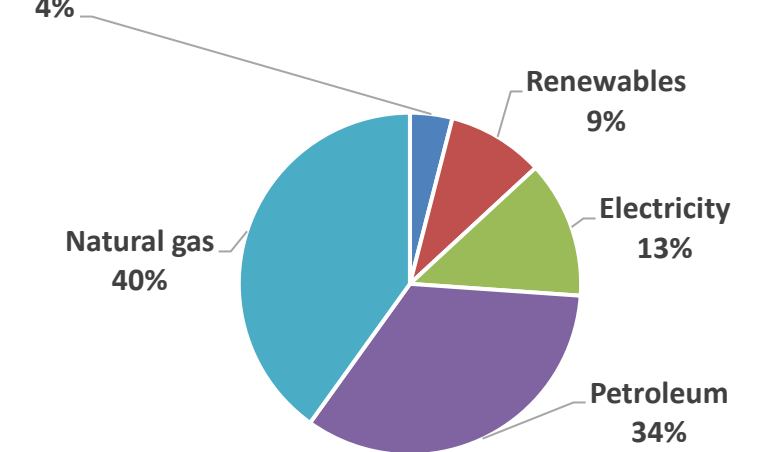


Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 2.4, April 2022, preliminary data for 2021



Note: Includes energy sources used as feedstocks in manufacturing products. Electricity is retail sales of electricity to the sector and excludes electric system energy losses associated with the retail sales.

## Energy Sources for industry in 2021



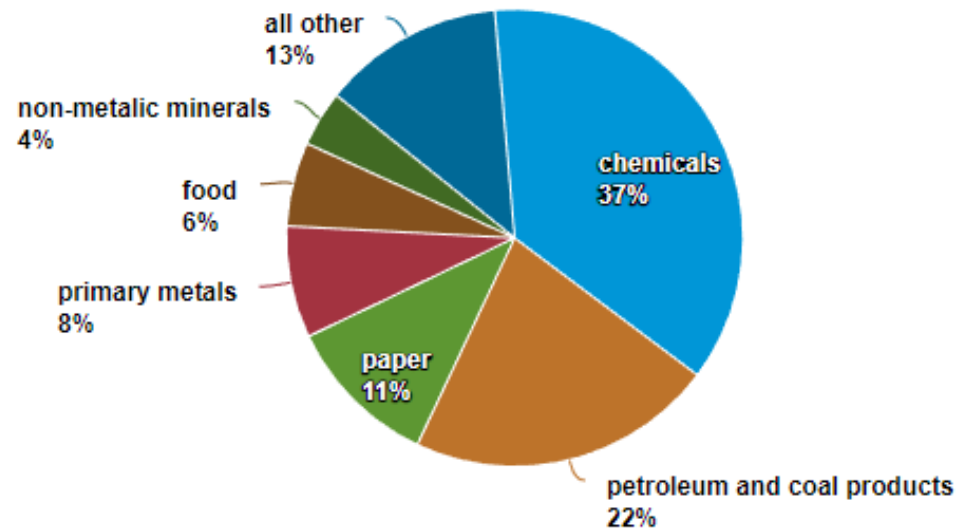
Highly dependent on the use of fossil fuels – Natural Gas (40%) and Petroleum (34%).

# Energy Consumption by Type of Subsectors



## U.S. manufacturing energy consumption by major types of manufacturers, 2018

total = 19.44 quadrillion British thermal units



Data source: U.S. Energy Information Administration, *Manufacturing Energy Consumption Survey 2018*, Table 1.2, February 2021



Note: Includes electricity purchases and energy sources used as feedstocks for making products. Sum of shares may not equal 100% because of independent rounding.

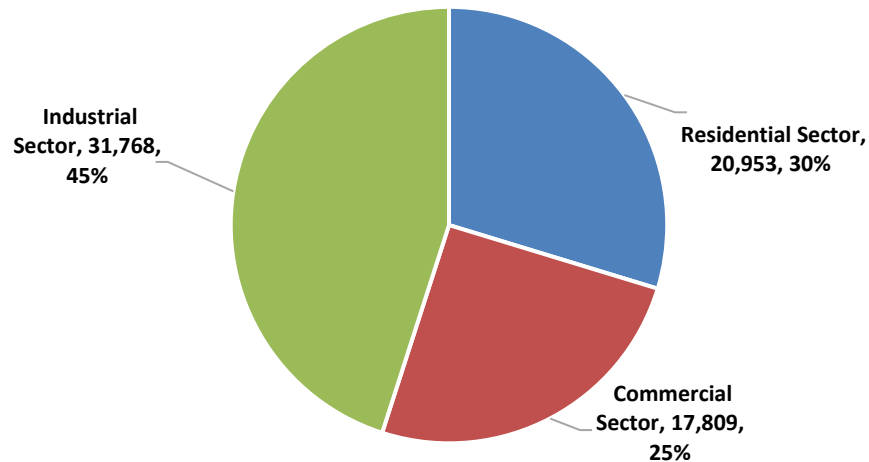
## Manufacturing energy consumption by subsector and type of energy in 2018 (trillion British thermal units)

Subsector	Fuel	Nonfuel	Total
Chemicals	2,815	4,326	7,141
Petroleum and coal products	3,342	903	4,245
Paper	2,488	3	2,491
Primary metals	1,734	307	2,041
Food	1,511		1,511
Nonmetallic minerals	1,161		1,161
All others	247	599	846
<b>Total</b>	<b>13,298</b>	<b>6,138</b>	<b>19,436</b>

# Participation and Energy Sources for Industrial Sector

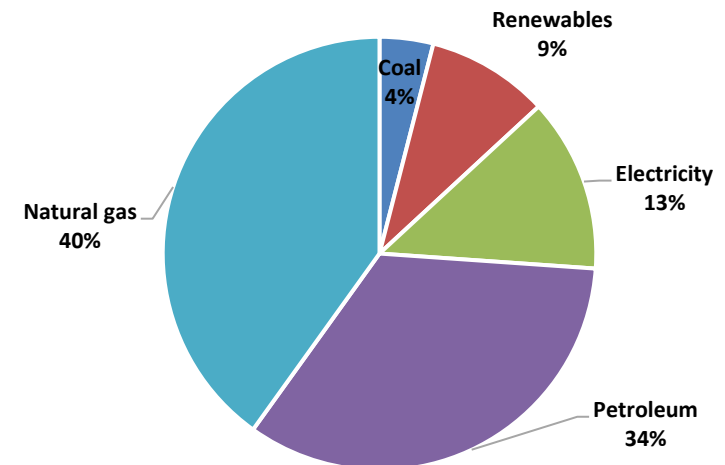


Average Annual Consumption by Sector  
2001 to 2021 (Trillion Btu)



On average, the Industrial Sector represents 45% of Total Energy Consumption in the USA, in the last 20 years (excluding Transportation).

Energy Sources for industry in 2021



Electricity represents only 13% of energy sources in the Industry Sector

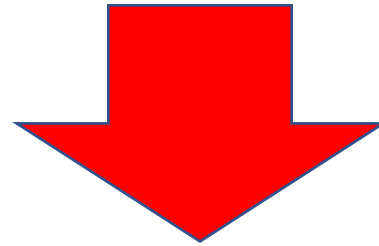


# Opportunities for Decarbonization



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Natural gas, petroleum, and coal represent 79% of other energy sources in the Industry Sector



**Around 56,000 Trillion BTU per year**

# Opportunities for Decarbonization



## U.S. Green Building Council: Chapter 8 – Energy & Atmosphere

### Primary goals:

- Reducing energy demand
- Increasing energy efficiency
- Replacing fossil fuels with renewable energy
- Eliminating the use of harmful refrigerants
- Monitoring ongoing performance



# Goal 1: Reducing Energy Demand



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## Strategies to Reduce Energy Demand

1. Reduce building footprint: reduce energy demand and construction costs
2. Incorporate passive solar design for heating and passive ventilation for cooling
3. Create a high-performance building envelope
4. Establish design and energy goals
5. Participate in a demand response program
  - a) **Demand-side management** (DSM) programs consist of the planning, implementing, and monitoring activities of electric utilities which are designed to encourage consumers to modify their level and pattern of electricity usage.

# Goal 2: Increasing Energy Efficiency



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## Strategies to Increase Energy Efficiency:

1. Install high-performance refrigeration systems, which typically cost more than less efficient systems. Utilize life-cycle costing to identify cost payback during a 20 years period
2. Implement normalized energy cost indicators, such as kWh per pound of product, or US\$ per pound of product
3. Analyze operation conditions
4. Establish a predictive maintenance program

*Considering energy efficiency, improvements after system start-up is suboptimal. **The best time to consider energy efficiency is ALL THE TIME.***

Industrial Refrigeration Energy Efficiency Guidebook  
Industrial Refrigeration Consortium - IRC

# Goal 3: Replacing Fossil Fuels with Renewable Energy



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## Strategies to Utilize Renewable Energy:

1. Install onsite renewable energy systems
2. Purchase off-site renewable energy

# Goal 4: Eliminating the Use of Harmful Refrigerants



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## Strategies to Eliminate Harmful Refrigerants

1. The goal is to eliminate the use of CFCs entirely and use more ozone-friendly refrigerants
2. Natural refrigerants such as ammonia ( $\text{NH}_3$ ) and carbon dioxide ( $\text{CO}_2$ ), are widely used in industrial refrigeration systems
3. Natural refrigerants are completed ozone-friendly options

# Goal 5: Monitoring Ongoing Performance



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## Strategies to Monitoring Ongoing Performance






1. Install a fully automated refrigeration system to adjust capacity based on the production thermal load
2. Monitoring of energy consumption
3. Create a set of Key Performance Indicators (KPI) to monitor ongoing performance
4. Establish benchmarks among different sites for performance improvement
5. Look for additional energy efficiency measures, based on measurement data

# Florida End-use Energy Consumption 2020





2.743 Trillion BTU (including Transportation)

## By Source

-  Coal – 0.2%
-  Natural Gas – 8.2%
-  Petroleum – 56.3%
-  Renewable Energy – 5.2%
-  Electricity – 30.1%

## By Type

-  Residential: 523.3 Trillion BTU – 39%
-  Commercial: 426.9 Trillion BTU – 32%
-  Industry: 375.7 T BTU – 28%

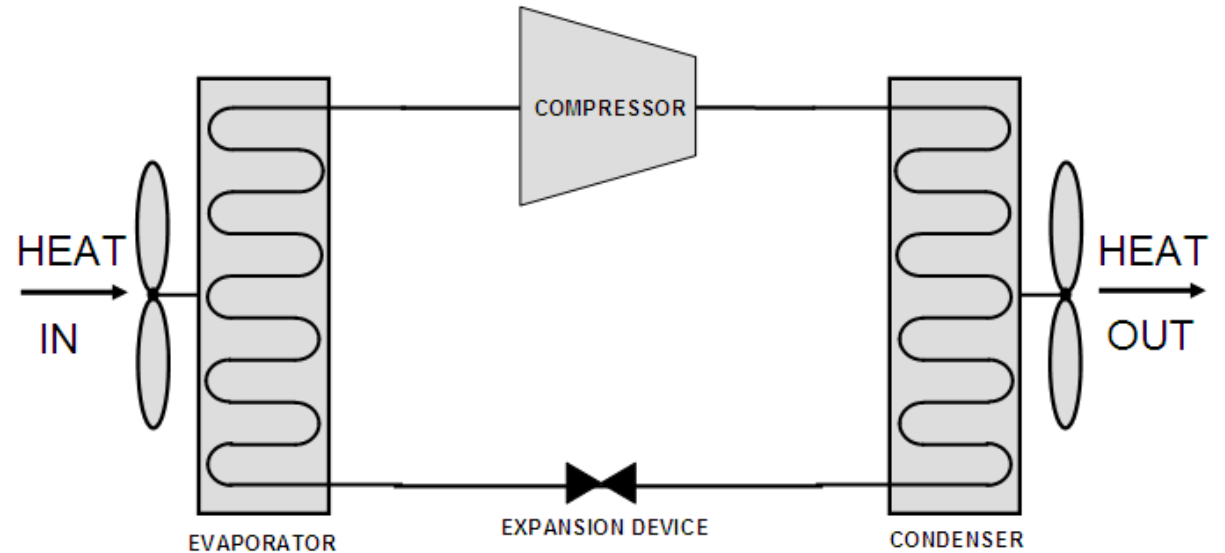


# Refrigeration Cycle



The refrigeration system transfers heat from one environment to another. The way heat is efficiently transferred, depends on several factors:

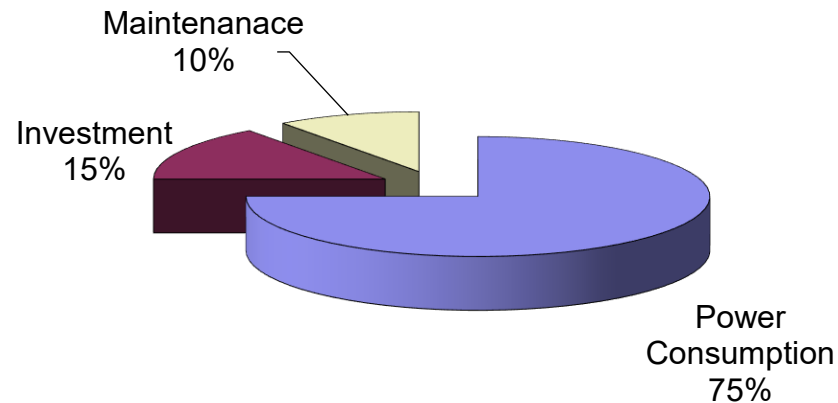
- Cooling system design
- Equipment efficiency
- Control and system automation
- Operation and maintenance



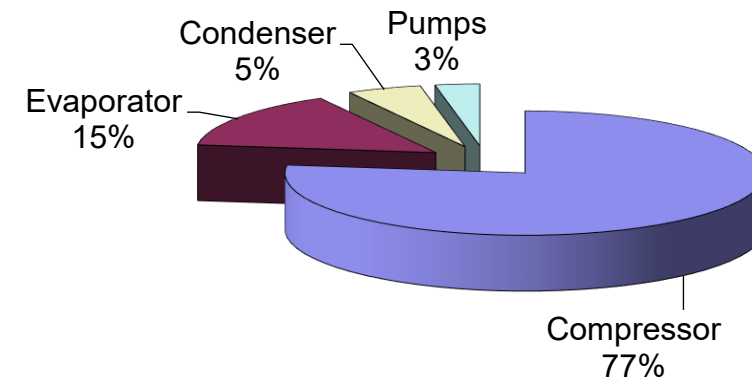
# Impact of Electricity on Industrial Refrigeration



## Total Cost of Ownership - 20 Years



## Estimated Consumption by Equipment



The Engine Room consumes approximately 70% of the electricity in the food processing industry.



# Business Description

## Value Proposition



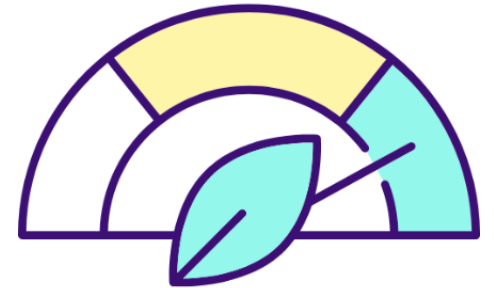
We are an independent consulting company with extensive expertise in industrial refrigeration. We are passionate about world sustainability and helping customers with their decarbonization and energy efficiency journeys to achieve Net Zero targets.



Decarbonization



Net Zero



Energy Efficiency



# Independent Consulting Services



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**Bennu Productions LLC** is an independent consultant provider to the Food & Beverage industry, by offering the following sustainability services:

- Analysis of current industrial refrigeration systems
- Evaluation of different industrial refrigeration system designs, looking for energy efficiency during the system life cycle
- Evaluation of heat pump utilization in the heating process, to reduce carbon emissions
- Evaluation of heat recovery opportunities
- Evaluation of Net Zero and Decarbonization opportunities
- Total cost of ownership analysis of different systems options