F-gas Reduction Incentive Program (FRIP): Commercial and Industrial Refrigeration

Benefits Quantification Examples

October 15, 2024

The following are hypothetical projects to demonstrate how greenhouse gas (GHG) benefits will be quantified in FRIP applications and how GHG benefits compare between different types of projects with similar charge sizes. These hypothetical projects do not provide examples of all of the information and supporting documentation that is required of actual project applicants.

Outcome Comparisons

Retail Food Refrigeration by Existing Refrigerant Type and Proposed System

Existing System	Proposed Replacement System	Total GHG Emissions Reductions ($MTCO_2e$)
Centralized DX system with 100 lb. of **R-507**	Transcritical system with 100 lb. of **CO_2**	600
Centralized DX system with 100 lb. of **R-22**	Transcritical system with 100 lb. of **CO_2**	272
Centralized DX system with 100 lb. of **R-448A or R-449A**	Transcritical system with 100 lb. of **CO_2**	209/210
Centralized DX system with 100 lb. of R-507	**Secondary/cascade** system with 50 lb. of R-448A and 50 lb. of glycol	528

Industrial Process Refrigeration Examples by Proposed Replacement Type

Existing System	Proposed Replacement System	Total GHG Emissions Reductions ($MTCO_2e$)
Centralized DX system with 2,000 lb. of R-507	**Centralized DX system** with 500 lb. of **ammonia**	9,761
Centralized DX system with 2,000 lb. of R-507	**Secondary/cascade** system with 1,000 lb. of **R-448A** and 1,000 lb. of glycol	8,869
Centralized DX system with 2,000 lb. of R-507	**Secondary/cascade** system with 1,000 lb. of **ammonia** and 1,000 lb. of glycol	9,761

Example #1 – Retail Food Refrigeration

- Full replacement of 2 existing high-GWP F-gas direct systems with 3 ultra-low-GWP direct systems

- FRIP funds requested: $500,000

Baseline System Inputs and Assumptions

Existing System Metrics	Existing System Inputs
Existing System #1	
System Type	Rack System
Refrigerant Type	R-22
Refrigerant Charge (lb)	500
Existing System #2	
System Type	Single or One-to-One System
Refrigerant Type	R-507
Refrigerant Charge (lb)	104

Average emission factors for existing system inputs:

- Annual Leak Rate:
  - 22.9% for system #1 (Retail Food Refrigeration systems with charge 200 – <2,000 lbs)
  - 15.6% for system #2 (Retail Food Refrigeration systems with charge >50 – <200 lbs)
- End-of-Life Leak Rate:
  - 20% for systems #1 and 2 (Refrigeration systems with charge ≥50 lbs)
- Quantification Period:
  - 15 years for system #1 (Retail Food Refrigeration systems with charge ≥200 lbs)
  - 20 years for system #2 (Retail Food Refrigeration systems with charge 50 – <200 lbs)

Proposed System Inputs and Assumptions

Proposed System Metrics	Proposed System Inputs
Proposed System #1	
System Type	Transcritical CO_2
Ultra-low-GWP Refrigerant Type	R-744 (carbon dioxide)
Ultra-low-GWP Refrigerant Charge (lb)	330
Proposed System #2	
System Type	Transcritical CO_2
Ultra-low-GWP Refrigerant Type	R-744 (carbon dioxide)
Ultra-low-GWP Refrigerant Charge (lb)	190
Proposed System #3	
System Type	Transcritical CO_2
Ultra-low-GWP Refrigerant Type	R-744 (carbon dioxide)
Ultra-low-GWP Refrigerant Charge (lb)	120

Average emission factors for proposed system inputs:

- Annual Leak Rate:
  - 22.9% for system #1 (Retail Food Refrigeration systems with charge 200 – <2,000 lbs)
  - 15.6% for systems #2 and 3 (Retail Food Refrigeration systems with charge >50 – <200 lbs)
- End-of-Life Leak Rate:
  - 20% for systems #1, 2, and 3 (Refrigeration systems with charge ≥50 lbs)
- Quantification Period:
  - 15 years for system #1 (Retail Food Refrigeration systems with charge ≥200 lbs)
  - 20 years for systems #2 and 3 (Retail Food Refrigeration systems with charge 50 – <200 lbs)

Benefits Summary

Benefits Metrics	Benefits Outputs
Total GHG Emission Reductions ($MTCO_2e$)	**2,115**
Baseline System GHG Emissions ($MTCO_2e$)	2,116
Proposed System GHG Emissions ($MTCO_2e$)	1
GHG Emission Reductions from HFC Reductions from Existing System to Mid-range GWP Refrigerant Retrofit Baseline ($MTCO_2e$)	405
GHG Emission Reductions from HFC Reductions from Mid-range GWP Refrigerant Retrofit Baseline to Ultra-low-GWP Technology ($MTCO_2e$)	219
High-GWP HFC Reductions (lb)	104
GHG Emission Reductions from High-GWP HFC Reductions ($MTCO_2e$)	624
High-GWP ODS Reductions (lb)	500
GHG Emission Reductions from High-GWP ODS Reductions ($MTCO_2e$)	1,492

Example #2 – Retail Food Refrigeration

- Replacement of 3 existing high-GWP F-gas direct systems with 1 ultra-low-GWP direct system and 1 ultra-low-GWP/HFC indirect system (includes both full and partial replacements)
- FRIP funds requested: $400,000

Baseline System Inputs and Assumptions

Existing System Metrics	Existing System Inputs
Existing System #1	
System Type	Centralized DX System
Refrigerant Type	R-404A
Refrigerant Charge (lb)	486
Existing System #2	
System Type	Rack System
Refrigerant Type	R-407A
Refrigerant Charge (lb)	350
Existing System #3	
System Type	Rack System
Refrigerant Type	R-407A
Refrigerant Charge (lb)	350

Average emission factors for existing system inputs:

- Annual Leak Rate:
  - 22.9% for systems #1, 2, and 3 (Retail Food Refrigeration systems with charge 200 – <2,000 lbs)
- End-of-Life Leak Rate:
  - 20% for systems #1, 2, and 3 (Refrigeration systems with charge ≥50 lbs)
- Quantification Period:
  - 15 years for systems #1, 2, and 3 (Retail Food Refrigeration systems with charge ≥200 lbs)

Proposed System Inputs and Assumptions

Proposed System Metrics	Proposed System Inputs
Proposed System #1	
System Type	Microdistributed System with Water Loop
Refrigerant Type	R-290 (propane)
Refrigerant Charge (lb)	20
Proposed System #2	
System Type	Secondary/Cascade System
Ultra-low-GWP Refrigerant Type	R-744 (carbon dioxide)
Ultra-low-GWP Refrigerant Charge (lb)	610
Primary Refrigerant Type	R-448A
Primary Refrigerant Charge (lb)	490

Average emission factors for proposed system inputs:

- Annual Leak Rate:

    - 1% for system #1 (Microdistributed Refrigeration systems)
    - 15.6% for system #2 (Indirect or Cascade Refrigeration systems)
- End-of-Life Leak Rate:
    - 98.5% for system #1 (Microdistributed Refrigeration systems)
    - 20% for system #2 (Refrigeration systems with charge ≥50 lbs)
- Quantification Period:
    - 14 years for system #1
    - 15 years for the ultra-low-GWP refrigerant in system #2 (Retail Food Refrigeration systems with charge ≥200 lbs)
    - 10 years for the primary refrigerant in system #2 (two-thirds of the quantification period for Retail Food Refrigeration systems with charge ≥200 lbs)

Benefits Summary

Benefits Metrics	Benefits Outputs
Total GHG Emission Reductions ($MTCO_2e$)	**5,029**[1]
Baseline System GHG Emissions ($MTCO_2e$)	5,575
Proposed System GHG Emissions ($MTCO_2e$)	545
GHG Emission Reductions from HFC Reductions from Existing System to Mid-range GWP Refrigerant Retrofit Baseline ($MTCO_2e$)	2,837
GHG Emission Reductions from HFC Reductions from Mid-range GWP Refrigerant Retrofit Baseline to Ultra-low-GWP Technology ($MTCO_2e$)	2,738
High-GWP HFC Reductions (lb)	1,186
GHG Emission Reductions from High-GWP HFC Reductions ($MTCO_2e$)	5,575
High-GWP ODS Reductions (lb)	0
GHG Emission Reductions from High-GWP ODS Reductions ($MTCO_2e$)	0

Example #3 – Industrial Process Refrigeration

- Full replacement of 1 existing high-GWP F-gas indirect system with 1 ultra-low-GWP indirect system
- FRIP funds requested: $500,000

[1] Total emissions may not equal baseline emissions minus proposed emissions due to rounding.

Baseline System Inputs and Assumptions

Existing System Metrics	Existing System Inputs
Existing System #1	
System Type	Secondary/Cascade System
Ultra-low-GWP Refrigerant Type	Glycol
Ultra-low-GWP Refrigerant Charge (lb)	3,000
Primary Refrigerant Type	R-404A
Primary Refrigerant Charge (lb)	2,342

Average emission factors for existing system inputs:

- Annual Leak Rate:
  - 9.1% (Indirect or Cascade Refrigeration systems)
- End-of-Life Leak Rate:
  - 20% (Refrigeration systems with charge ≥50 lbs)
- Quantification Period:
  - 20 years for the ultra-low-GWP refrigerant (Industrial Process Refrigeration)
  - 13 years for the primary refrigerant (two-thirds of the quantification period for Industrial Process Refrigeration)

Proposed System Inputs and Assumptions

Proposed System Metrics	Proposed System Inputs
Proposed System #1	
System Type	Secondary/Cascade System
Ultra-low-GWP Refrigerant Type	Glycol
Ultra-low-GWP Refrigerant Charge (lb)	3,000
Primary Refrigerant Type	R-717 (ammonia)
Primary Refrigerant Charge (lb)	1,000

Average emission factors for proposed system inputs:

- Annual Leak Rate:
  - 9.1% (Indirect or Cascade Refrigeration systems)
- End-of-Life Leak Rate:
  - 20% (Refrigeration systems with charge ≥50 lbs)
- Quantification Period:
  - 20 years for the ultra-low-GWP refrigerant (Industrial Process Refrigeration)
  - 13 years for the primary refrigerant (two-thirds of the quantification period for Industrial Process Refrigeration)

Benefits Summary

Benefits Metrics	Benefits Outputs
Total GHG Emission Reductions ($MTCO_2e$)	**5,914**
Baseline System GHG Emissions ($MTCO_2e$)	5,914
Proposed System GHG Emissions ($MTCO_2e$)	0
GHG Emission Reductions from HFC Reductions from Existing System to Mid-range GWP Refrigerant Retrofit Baseline ($MTCO_2e$)	2,597
GHG Emission Reductions from HFC Reductions from Mid-range GWP Refrigerant Retrofit Baseline to Ultra-low-GWP Technology ($MTCO_2e$)	3,317
High-GWP HFC Reductions (lb)	2,342
GHG Emission Reductions from High-GWP HFC Reductions ($MTCO_2e$)	5,914
High-GWP ODS Reductions (lb)	0
GHG Emission Reductions from High-GWP ODS Reductions ($MTCO_2e$)	0

Example #4 – Cold Storage

- Full Replacement of 2 existing high-GWP F-gas direct systems with 2 ultra-low-GWP direct systems
- FRIP funds requested: $500,000

Baseline System Inputs and Assumptions

Existing System Metrics	Existing System Inputs
Existing System #1	
System Type	Centralized DX System
Refrigerant Type	R-22
Refrigerant Charge (lb)	1,729
Existing System #2	
System Type	Single or One-to-One System
Refrigerant Type	R-507
Refrigerant Charge (lb)	45

Assumptions based on existing system inputs:

- Annual Leak Rate:
  - 10.3% for system #1 (Cold Storage Refrigeration systems with charge 200 – <2,000 lbs)
  - 15% for system #2 (Refrigeration systems with charge ≤50 lbs)
- End-of-Life Leak Rate:

  - 20% for system #1 (Refrigeration systems with charge ≥50 lbs)
  - 34% for system #2 (Refrigeration systems with charge <50 lbs)
- Quantification Period:
  - 20 years for systems #1 and 2 (Cold Storage or Other Refrigeration)

Proposed System Inputs and Assumptions

Proposed System Metrics	Proposed System Inputs
Proposed System #1	
System Type	Transcritical CO_2
Ultra-low-GWP Refrigerant Type	R-744 (carbon dioxide)
Ultra-low-GWP Refrigerant Charge (lb)	1,793
Proposed System #2	
System Type	Single or One-to-One System
Ultra-low-GWP Refrigerant Type	R-744 (carbon dioxide)
Ultra-low-GWP Refrigerant Charge (lb)	45

Assumptions based on proposed system inputs:

- Annual Leak Rate:
  - 10.3% for system #1 (Cold Storage Refrigeration systems with charge 200 – <2,000 lbs)
  - 15% for system #2 (Refrigeration systems with charge ≤50 lbs)
- End-of-Life Leak Rate:
  - 20% for system #1 (Refrigeration systems with charge ≥50 lbs)
  - 34% for system #2 (Refrigeration systems with charge <50 lbs)
- Quantification Period:
  - 20 years for systems #1 and 2 (Cold Storage or Other Refrigeration)

Benefits Summary

Benefits Metrics	Benefits Outputs
Total GHG Emission Reductions ($MTCO_2e$)	**3,478**
Baseline System GHG Emissions ($MTCO_2e$)	3,480
Proposed System GHG Emissions ($MTCO_2e$)	2
GHG Emission Reductions from HFC Reductions from Existing System to Mid-range GWP Refrigerant Retrofit Baseline ($MTCO_2e$)	177
GHG Emission Reductions from HFC Reductions from Mid-range GWP Refrigerant Retrofit Baseline to Ultra-low-GWP Technology ($MTCO_2e$)	95
High-GWP HFC Reductions (lb)	45
GHG Emission Reductions from High-GWP HFC Reductions ($MTCO_2e$)	272

Benefits Metrics	Benefits Outputs
High-GWP ODS Reductions (lb)	1,729
GHG Emission Reductions from High-GWP ODS Reductions ($MTCO_2e$)	3,208