RACC Tool Refrigerant Charge Update Guide

Supplementary Guide

ET25SWE0036 and ET25SWE0037

Prepared by:
Parker Wall, TRC

Aaron Kwon, TRC

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Abbreviations and Acronyms

Acronym	Meaning
CARB	California Air Resources Board
CPUC	California Public Utilities Commission
DEER	Database for Energy Efficiency Resources
EPA	United States Environmental Protection Agency
eTRM	Electronic Technical Reference Manual
GHG	Greenhouse Gas
GHGE Inventory	Appendix B of California Facilities and Greenhouse Gas Emissions Inventory – High-Global Warming Potential Stationary Source Refrigerant Management Program
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor-Owned Utility
PG&E	Pacific Gas & Electric
RACC	Refrigerant Avoided Cost Calculator
RACC-FSC_v3.1 Tool	Combined Refrigerant Avoided Cost and Fuel-Substitution Calculators, Version 3.1
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric

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Introduction

The research team developed this guide on behalf of the California Public Utilities Commission (CPUC) and CalNEXT to support the research reports on improving refrigerant charge amounts of residential and commercial HVAC equipment. These reports propose updates to the underlying data tables in the Database for Energy Efficiency Resources (DEER) and Combined Refrigerant Avoided Cost and Fuel-Substitution Calculators, Version 3.1 (RACC-FSC_v3.1 Tool) (collectively referred to as 'RACC Tools').

This supplementary guide provides stakeholders with detailed guidance on how to implement the recommended refrigerant charge values proposed in the RACC Tools. This guide:

- Highlights all tabs affected by updates to refrigerant charge values
- Identifies Tables and columns requiring updates
- Recommends updates to current RACC Tool functions

RACC Tool Update Guide

This guide reviews the current RACC Tool and identifies the specific values affected by updates to refrigerant charge values to set a basic understanding of which tables are to be impacted by the research team's study of refrigerant charge values. This guide includes figures directly sourced from the RACC-FSC_v3.1 Tool. Recommended equipment categories and refrigerant charge values can be found in Appendix A.

This guide gives detailed overviews of individual sheets and functions within the RACC Tool including why and how the research team recommends they be updated. All updates to equipment categories and refrigerant charge values should be accompanied by a quality review to ensure that all references to updated values are maintained. The following is a list of the recommended updates:

- **'0 Refrig Research' sheet, columns B and C**: Update equipment categories and corresponding common refrigerant
- **'0 Refrig Research' sheet, columns E and F**: Update refrigerant charge values and Normunit
- **'1 Device Builder' sheet, column K**: Update baseline refrigerant charge values
- **'CARB_RefrigLeaks_DEER' sheet, column B**: Update equipment categories
- **'CARB_RefrigLeaks_DEER' sheet, column F**: Update refrigerant charge values

The recommended equipment categories are included in Appendix Table 1 and Table 4 .

The recommended refrigerant charge values are included in Appendix Table 2 and Table 5.

RACC Tool Overview

The following sections address individual sheets in the RACC-FSC_v3.1 Tool and indicate what values require updates to incorporate the research team's recommended equipment types and refrigerant charge values.

0 Refrig Research

'0 Refrig Research' currently contains the accumulated refrigerant charge values used to set the referenced values called by the '2 RACC' sheet. This sheet is not linked to the '1 Device Builder' sheet since it is difficult to enforce consistent naming conventions. Figure 1 shows two columns (E and F) that tabulates 'Refrigerant Charge' and 'NormUnit'.

- **Columns B** to be updated to include recommended HVAC equipment categories.
- **Column C** to be updated to include recommended common refrigerant categories for the respective HVAC equipment types.
- **Columns E** to be updated to the recommended refrigerant charge values.
- **Column F** to be updated to the recommended NormUnit values.

Figure 1: Sheet '0 Refrig Research' with highlighted columns B, C, E, and F that have recommended updates

	A	B	C	D	E	F
3						
4						
5		CARB_DeviceType	Common Refrigerant Type(s)	Source for Refrigerant Type	Refrigerant Charge (lb/NormUnit)	NormUnit
6		Heat Pump Clothes Dryers	R-134A|R-407C|R-410A	1) https://www.choice.com.au/home-and-living/laundry-and-cleaning/dryers/articles/what-is-a-heat-pump-dryer 2) https://www.researchgate.net/publication/280446701_The_Design_of_Heat_Pump_Clothes_Dryer	0.88	Each
7		Ductless HVAC, Residential - Heat Pump	R-410A	Table 5-5 CPUC. Proposed Defined Study – A Roadmap for Accelerating the Adoption of Low-Global Warming Potential HVAC Refrigerants, EM&V Group A. March 4, 2021	3.50	Cap-Tons
8		Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential	R-410A	Table 5-5 CPUC. Proposed Defined Study – A Roadmap for Accelerating the Adoption of Low-Global Warming Potential HVAC Refrigerants, EM&V Group A. March 4, 2021	1.54	Each
9		Central HVAC, Residential - Heat Pump	R-410A	Table 5-5 CPUC. Proposed Defined Study – A Roadmap for Accelerating the Adoption of Low-Global Warming Potential HVAC Refrigerants, EM&V Group A. March 4, 2021	3.50	Cap-Tons
10		Residential Unitary AC	R-410A	Table 5-5 CPUC. Proposed Defined Study – A Roadmap for Accelerating the Adoption of Low-Global Warming Potential HVAC Refrigerants, EM&V Group A. March 4, 2021	3.20	Each
11		Unitary Air-Cooled HVAC, Commercial - Heat Pump	R-410A	Table 5-5 CPUC. Proposed Defined Study – A Roadmap for Accelerating the Adoption of Low-Global Warming Potential HVAC Refrigerants, EM&V Group A. March 4, 2021	3.50	Cap-Tons
12		Commercial Unitary AC, < 50-lbs., < 135,000 BTUh size (includes smaller "residential-type" central AC and heat pumps)	R-410A	Table 5-5 CPUC. Proposed Defined Study – A Roadmap for Accelerating the Adoption of Low-Global Warming Potential HVAC Refrigerants, EM&V Group A. March 4, 2021	3.20	Cap-Tons
13		Pool Heater, Residential - Heat Pump	R-410A	AHRI database has 407 heat pump pool heaters listed and all have R-410a as the refrigerant type	5.38	Each
14		Heat Pump Water Heaters	R-134A|R-410A	1. https://www.osti.gov/servlets/purl/1468227 2."Refrigerants for Heat Pump Water Heaters, Report Annex 46 HPT-AN46-04", December 2019, Compiled and Edited by Onno Kleefkens M.Sc. for IEA TCP-HPT, Published by Heat Pump Centre. 3. https://heatpumpingtechnologies.org/annex46/wp-content/uploads/sites/53/2020/10/hpt-an46-04-task-1-refrigerants-for-heat-pump-water-heaters-1.pdf	2.40	Each
15		Large Water Heater, Multifamily/Commercial - Heat Pump	R-134A	1. https://www.osti.gov/servlets/purl/1468227 2."Refrigerants for Heat Pump Water Heaters, Report Annex 46 HPT-AN46-04", December 2019, Compiled and Edited by Onno Kleefkens M.Sc. for IEA TCP-HPT, Published by Heat Pump Centre. 3. https://heatpumpingtechnologies.org/annex46/wp-content/uploads/sites/53/2020/10/hpt-an46-04-task-1-refrigerants-for-heat-pump-water-heaters-1.pdf	0.19	Cap-kBTUh
16		Water Heater, Commercial - Heat Pump	R-134A	1. https://www.osti.gov/servlets/purl/1468227 2."Refrigerants for Heat Pump Water Heaters, Report Annex 46 HPT-AN46-04", December 2019, Compiled and Edited by Onno Kleefkens M.Sc. for IEA TCP-HPT, Published by Heat Pump Centre. 3. https://heatpumpingtechnologies.org/annex46/wp-content/uploads/sites/53/2020/10/hpt-an46-04-task-1-refrigerants-for-heat-pump-water-heaters-1.pdf	3.30	Each
17		Residential HVAC Heat Pumps	R-410A		3.50	Each

1 Device Builder

This sheet is used to define the equipment (device types) to be used in the '2 RACC' sheet. Figure 2 shows relevant columns in the '1 Device Builder' sheet. Column J references 'CARB_Refrig_Leaks_DEER', seen in CARB_RefrigLeaks_DEER

The 'CARB_RefrigLeaks_DEER' sheet currently sources data from a DEER database table that contains typical refrigerant leakage rates (annual and end-of-life) by equipment type from CARB data. The '2 RACC' sheet references this sheet to populate default refrigerant leakage values, but does not

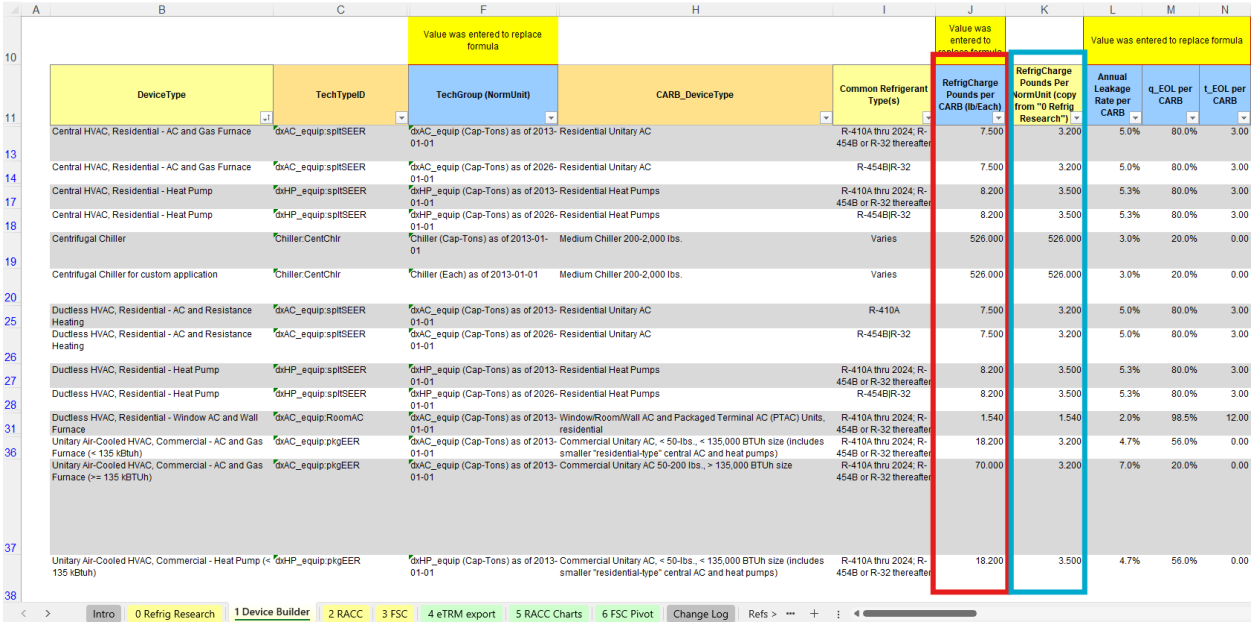
directly reference this sheet for refrigerant charge values. This sheet also contains CARB_DeviceTypes and average charge values that are referenced by the '0 Refrig Research' and '1 Device Builder' sheets. Figure 3 shows the device types that are within the scope of the research team's study. The research team recommends the following updates to 'CARB_RefrigLeaks_DEER':

- **Column B** to be updated with the research team's recommended equipment categories for the HVAC equipment.
    - When updating Column B, verify that leakage values are accurately assigned to new equipment categories. Reference Table 1 and Table 4 to assign values based on existing equipment category type. *Example: New equipment categories Residential Split AC, Residential Packaged AC and Ductless Mini Split AC should all contain leakage values of existing equipment category Residential Unitary AC.*
- **Column F** to be updated with the research team's recommended refrigerant charge values for the respective equipment categories.

Figure 3, to populate average charge values depending on inputs in Column H on 'CARB_DeviceType'. Column J is not referenced by the RACC but serves as a reference to populate Column K. No updates are required to Column J provided that the 'CARB_Refrig_Leaks_DEER' sheet is updated. The internal reference should be confirmed to still be operational so that Column J pulls from the CARB_Refrig_Leaks_DEER sheet after all updates are made.

Column K is a user-defined column with the preset values shown in Figure 2 that is referenced by the RACC to estimate refrigerant charge and directly influences the total system benefit. As mentioned in the previous section, Column K intentionally does not contain a formula to deduce refrigerant charge based on other entries due to difficulty in enforcing a consistent naming convention. Refrigerant charge values for relevant equipment types should be updated for existing devices built into default template. Otherwise, since the values in Column K are user-defined, no additional updates are required.

Figure 2: Columns J and K from '1 Device Builder'



DeviceType	TechTypeID	TechGroup (NormUnit)	CARB_DeviceType	Common Refrigerant Type(s)	RefrigCharge Pounds per CARB (lb/Each)	RefrigCharge Pounds Per NormUnit (copy from "0 Refrig Research")	Annual Leakage Rate per CARB	q_EOL_per CARB	t_EOL per CARB
		Value was entered to replace formula			Value was entered to replace formula		Value was entered to replace formula		
Central HVAC, Residential - AC and Gas Furnace	dxAC_equip:spltSEER	dxAC_equip (Cap-Tons) as of 2013-01-01	Residential Unitary AC	R-410A thru 2024; R-454B or R-32 thereafter	7.500	3.200	5.0%	80.0%	3.00
Central HVAC, Residential - AC and Gas Furnace	dxAC_equip:spltSEER	dxAC_equip (Cap-Tons) as of 2026-01-01	Residential Unitary AC	R-454B|R-32	7.500	3.200	5.0%	80.0%	3.00
Central HVAC, Residential - Heat Pump	dxHP_equip:spltSEER	dxHP_equip (Cap-Tons) as of 2013-01-01	Residential Heat Pumps	R-410A thru 2024; R-454B or R-32 thereafter	8.200	3.500	5.3%	80.0%	3.00
Central HVAC, Residential - Heat Pump	dxHP_equip:spltSEER	dxHP_equip (Cap-Tons) as of 2026-01-01	Residential Heat Pumps	R-454B|R-32	8.200	3.500	5.3%	80.0%	3.00
Centrifugal Chiller	Chiller:CentChlr	Chiller (Cap-Tons) as of 2013-01-01	Medium Chiller 200-2,000 lbs.	Varies	526.000	526.000	3.0%	20.0%	0.00
Centrifugal Chiller for custom application	Chiller:CentChlr	Chiller (Each) as of 2013-01-01	Medium Chiller 200-2,000 lbs.	Varies	526.000	526.000	3.0%	20.0%	0.00
Ductless HVAC, Residential - AC and Resistance Heating	dxAC_equip:spltSEER	dxAC_equip (Cap-Tons) as of 2013-01-01	Residential Unitary AC	R-410A	7.500	3.200	5.0%	80.0%	3.00
Ductless HVAC, Residential - AC and Resistance Heating	dxAC_equip:spltSEER	dxAC_equip (Cap-Tons) as of 2026-01-01	Residential Unitary AC	R-454B|R-32	7.500	3.200	5.0%	80.0%	3.00
Ductless HVAC, Residential - Heat Pump	dxHP_equip:spltSEER	dxHP_equip (Cap-Tons) as of 2013-01-01	Residential Heat Pumps	R-410A thru 2024; R-454B or R-32 thereafter	8.200	3.500	5.3%	80.0%	3.00
Ductless HVAC, Residential - Heat Pump	dxHP_equip:spltSEER	dxHP_equip (Cap-Tons) as of 2026-01-01	Residential Heat Pumps	R-454B|R-32	8.200	3.500	5.3%	80.0%	3.00
Ductless HVAC, Residential - Window AC and Wall Furnace	dxAC_equip:RoomAC	dxAC_equip (Cap-Tons) as of 2013-01-01	Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential	R-410A thru 2024; R-454B or R-32 thereafter	1.540	1.540	2.0%	98.5%	12.00
Unitary Air-Cooled HVAC, Commercial - AC and Gas Furnace (< 135 kBtuh)	dxAC_equip:pkgEER	dxAC_equip (Cap-Tons) as of 2013-01-01	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh size (includes smaller "residential-type" central AC and heat pumps)	R-410A thru 2024; R-454B or R-32 thereafter	18.200	3.200	4.7%	56.0%	0.00
Unitary Air-Cooled HVAC, Commercial - AC and Gas Furnace (>= 135 kBTUh)	dxAC_equip:pkgEER	dxAC_equip (Cap-Tons) as of 2013-01-01	Commercial Unitary AC 50-200 lbs., > 135,000 BTUh size	R-410A thru 2024; R-454B or R-32 thereafter	70.000	3.200	7.0%	20.0%	0.00
Unitary Air-Cooled HVAC, Commercial - Heat Pump (< 135 kBtuh)	dxHP_equip:pkgEER	dxHP_equip (Cap-Tons) as of 2013-01-01	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh size (includes smaller "residential-type" central AC and heat pumps)	R-410A thru 2024; R-454B or R-32 thereafter	18.200	3.500	4.7%	56.0%	0.00

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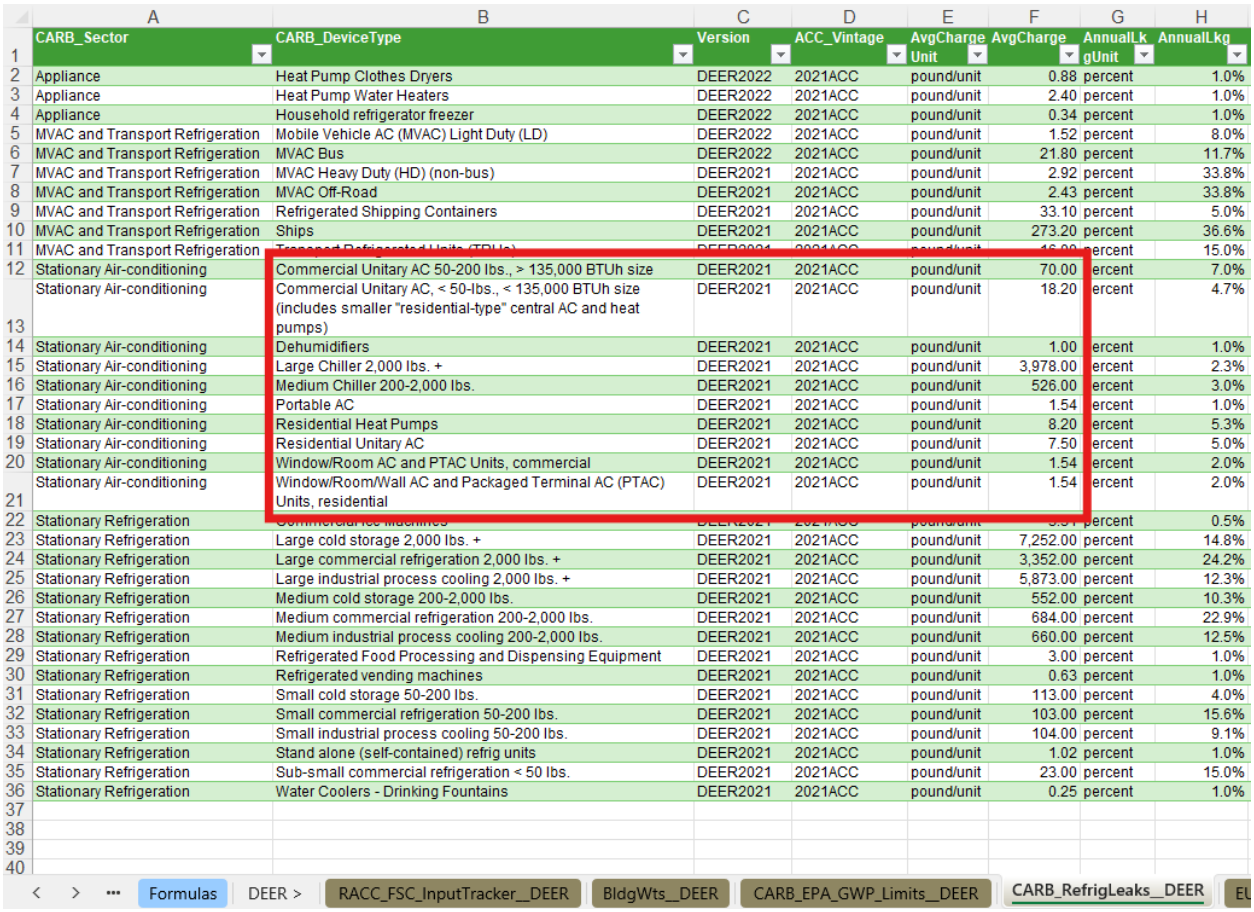
CARB_RefrigLeaks_DEER

The 'CARB_RefrigLeaks_DEER' sheet currently sources data from a DEER database table that contains typical refrigerant leakage rates (annual and end-of-life) by equipment type from CARB data. The '2 RACC' sheet references this sheet to populate default refrigerant leakage values, but does not directly reference this sheet for refrigerant charge values. This sheet also contains CARB_DeviceTypes and average charge values that are referenced by the '0 Refrig Research' and '1 Device Builder' sheets. Figure 3 shows the device types that are within the scope of the research team's study. The research team recommends the following updates to 'CARB_RefrigLeaks_DEER':

- **Column B** to be updated with the research team's recommended equipment categories for the HVAC equipment.
    - When updating Column B, verify that leakage values are accurately assigned to new equipment categories. Reference Table 1 and Table 4 to assign values based on existing equipment category type. *Example: New equipment categories Residential Split AC, Residential Packaged AC and Ductless Mini Split AC should all contain leakage values of existing equipment category Residential Unitary AC.*
- **Column F** to be updated with the research team's recommended refrigerant charge values for the respective equipment categories.

Figure 3: Equipment Types and AvgCharge from 'CARB_RefrigLeaks_DEER'



	A	B	C	D	E	F	G	H
1	CARB_Sector	CARB_DeviceType	Version	ACC_Vintage	AvgCharge Unit	AvgCharge	AnnualLkgUnit	AnnualLkg
2	Appliance	Heat Pump Clothes Dryers	DEER2022	2021ACC	pound/unit	0.88	percent	1.0%
3	Appliance	Heat Pump Water Heaters	DEER2022	2021ACC	pound/unit	2.40	percent	1.0%
4	Appliance	Household refrigerator freezer	DEER2022	2021ACC	pound/unit	0.34	percent	1.0%
5	MVAC and Transport Refrigeration	Mobile Vehicle AC (MVAC) Light Duty (LD)	DEER2022	2021ACC	pound/unit	1.52	percent	8.0%
6	MVAC and Transport Refrigeration	MVAC Bus	DEER2022	2021ACC	pound/unit	21.80	percent	11.7%
7	MVAC and Transport Refrigeration	MVAC Heavy Duty (HD) (non-bus)	DEER2021	2021ACC	pound/unit	2.92	percent	33.8%
8	MVAC and Transport Refrigeration	MVAC Off-Road	DEER2021	2021ACC	pound/unit	2.43	percent	33.8%
9	MVAC and Transport Refrigeration	Refrigerated Shipping Containers	DEER2021	2021ACC	pound/unit	33.10	percent	5.0%
10	MVAC and Transport Refrigeration	Ships	DEER2021	2021ACC	pound/unit	273.20	percent	36.6%
11	MVAC and Transport Refrigeration	Transport Refrigerated Units (TRUs)	DEER2021	2021ACC	pound/unit	16.00	percent	15.0%
12	Stationary Air-conditioning	Commercial Unitary AC 50-200 lbs., > 135,000 BTUh size	DEER2021	2021ACC	pound/unit	70.00	percent	7.0%
13	Stationary Air-conditioning	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh size (includes smaller "residential-type" central AC and heat pumps)	DEER2021	2021ACC	pound/unit	18.20	percent	4.7%
14	Stationary Air-conditioning	Dehumidifiers	DEER2021	2021ACC	pound/unit	1.00	percent	1.0%
15	Stationary Air-conditioning	Large Chiller 2,000 lbs. +	DEER2021	2021ACC	pound/unit	3,978.00	percent	2.3%
16	Stationary Air-conditioning	Medium Chiller 200-2,000 lbs.	DEER2021	2021ACC	pound/unit	526.00	percent	3.0%
17	Stationary Air-conditioning	Portable AC	DEER2021	2021ACC	pound/unit	1.54	percent	1.0%
18	Stationary Air-conditioning	Residential Heat Pumps	DEER2021	2021ACC	pound/unit	8.20	percent	5.3%
19	Stationary Air-conditioning	Residential Unitary AC	DEER2021	2021ACC	pound/unit	7.50	percent	5.0%
20	Stationary Air-conditioning	Window/Room AC and PTAC Units, commercial	DEER2021	2021ACC	pound/unit	1.54	percent	2.0%
21	Stationary Air-conditioning	Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential	DEER2021	2021ACC	pound/unit	1.54	percent	2.0%
22	Stationary Refrigeration	Commercial Ice Machines	DEER2021	2021ACC	pound/unit	0.54	percent	0.5%
23	Stationary Refrigeration	Large cold storage 2,000 lbs. +	DEER2021	2021ACC	pound/unit	7,252.00	percent	14.8%
24	Stationary Refrigeration	Large commercial refrigeration 2,000 lbs. +	DEER2021	2021ACC	pound/unit	3,352.00	percent	24.2%
25	Stationary Refrigeration	Large industrial process cooling 2,000 lbs. +	DEER2021	2021ACC	pound/unit	5,873.00	percent	12.3%
26	Stationary Refrigeration	Medium cold storage 200-2,000 lbs.	DEER2021	2021ACC	pound/unit	552.00	percent	10.3%
27	Stationary Refrigeration	Medium commercial refrigeration 200-2,000 lbs.	DEER2021	2021ACC	pound/unit	684.00	percent	22.9%
28	Stationary Refrigeration	Medium industrial process cooling 200-2,000 lbs.	DEER2021	2021ACC	pound/unit	660.00	percent	12.5%
29	Stationary Refrigeration	Refrigerated Food Processing and Dispensing Equipment	DEER2021	2021ACC	pound/unit	3.00	percent	1.0%
30	Stationary Refrigeration	Refrigerated vending machines	DEER2021	2021ACC	pound/unit	0.63	percent	1.0%
31	Stationary Refrigeration	Small cold storage 50-200 lbs.	DEER2021	2021ACC	pound/unit	113.00	percent	4.0%
32	Stationary Refrigeration	Small commercial refrigeration 50-200 lbs.	DEER2021	2021ACC	pound/unit	103.00	percent	15.6%
33	Stationary Refrigeration	Small industrial process cooling 50-200 lbs.	DEER2021	2021ACC	pound/unit	104.00	percent	9.1%
34	Stationary Refrigeration	Stand alone (self-contained) refrig units	DEER2021	2021ACC	pound/unit	1.02	percent	1.0%
35	Stationary Refrigeration	Sub-small commercial refrigeration < 50 lbs.	DEER2021	2021ACC	pound/unit	23.00	percent	15.0%
36	Stationary Refrigeration	Water Coolers - Drinking Fountains	DEER2021	2021ACC	pound/unit	0.25	percent	1.0%
37								
38								
39								
40								

Formulas | DEER > | RACC_FSC_InputTracker__DEER | BldgWts__DEER | CARB_EPA_GWP_Limits__DEER | CARB_RefrigLeaks__DEER | EU

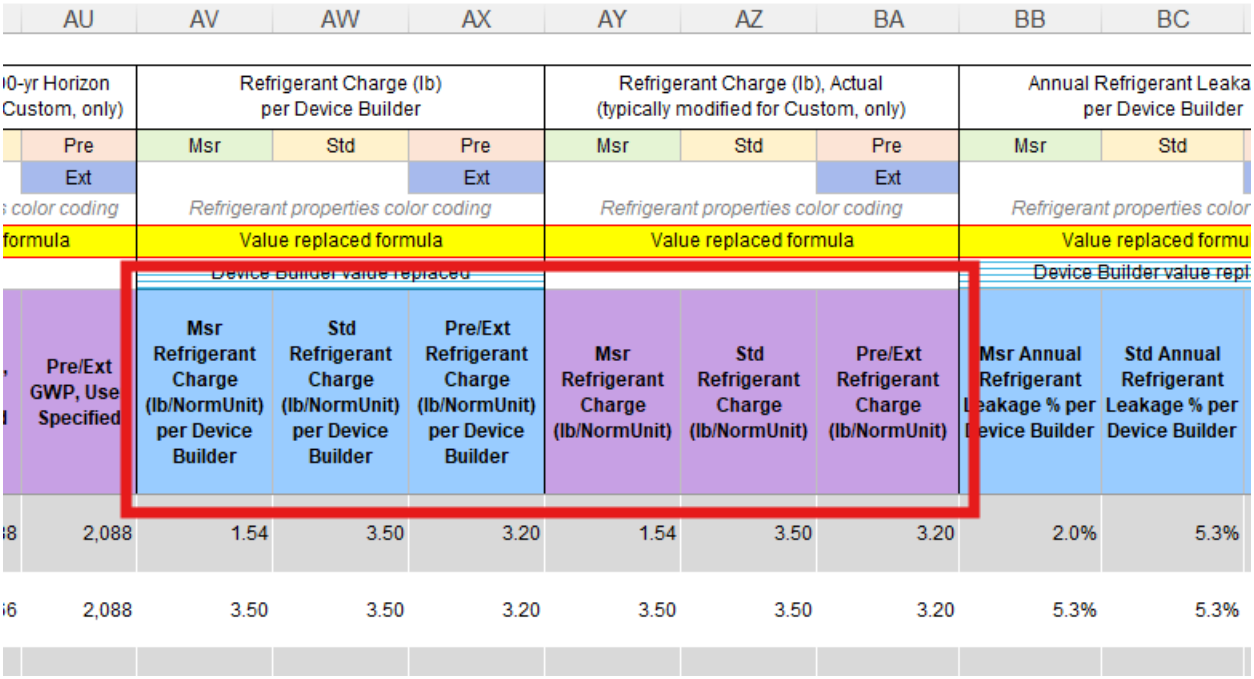
2 RACC

The '2 RACC' sheet is where users define the necessary inputs for the measure case and counterfactual case parameters of the activity to generate an avoided cost value.

Figure 4 shows the columns that populate based on Column K of the ‘1 Device Builder’ sheet. Columns AY through BA are for custom inputs (see Figure 6).

No updates are required to this sheet, as it is automatically populated by other sheets and does not contain any static values..

Figure 4: Columns affected by recommended changes in '2 RACC'



AU	AV	AW	AX	AY	AZ	BA	BB	BC
)0-yr Horizon Custom, only)	Refrigerant Charge (lb) per Device Builder			Refrigerant Charge (lb), Actual (typically modified for Custom, only)			Annual Refrigerant Leaka per Device Builder	
Pre	Msr	Std	Pre	Msr	Std	Pre	Msr	Std
Ext			Ext			Ext		
color coding	*Refrigerant properties color coding*			*Refrigerant properties color coding*			*Refrigerant properties color*	
formula	Value replaced formula			Value replaced formula			Value replaced formu	
	Device Builder value replaced						Device Builder value repl	
Pre/Ext GWP, Use Specified	**Msr Refrigerant Charge (lb/NormUnit) per Device Builder**	**Std Refrigerant Charge (lb/NormUnit) per Device Builder**	**Pre/Ext Refrigerant Charge (lb/NormUnit) per Device Builder**	**Msr Refrigerant Charge (lb/NormUnit)**	**Std Refrigerant Charge (lb/NormUnit)**	**Pre/Ext Refrigerant Charge (lb/NormUnit)**	**Msr Annual Refrigerant eakage % per evice Builder**	**Std Annual Refrigerant Leakage % per Device Builder**
2,088	1.54	3.50	3.20	1.54	3.50	3.20	2.0%	5.3%
2,088	3.50	3.50	3.20	3.50	3.50	3.20	5.3%	5.3%

Figure 5 shows the formulas contained in columns AV through BA in

Figure 4. These formulas reveal the relationship between these columns and Column K of the '1 Device Builder' sheet.

Figure 5: Formulas for Affected Columns from '2 RACC'

Sheet	Col. No.	Col. Label	Header	Original formula in row 10
2 RACC	48	AV	Msr Refrigerant Charge (lb/NormUnit) per Device Builder	=IFERROR(INDEX(Device_Builds_Table,MATCH(1,($I10=Device_Builds_Table[TechGroup (NormUnit)])*($J10=Device_Builds_Table[DeviceType]),0),MATCH('1 Device Builder'!$K$11,Device_Builds_Table[#Headers],0)),"")
2 RACC	49	AW	Std Refrigerant Charge (lb/NormUnit) per Device Builder	=IFERROR(INDEX(Device_Builds_Table,MATCH(1,($O10=Device_Builds_Table[TechGroup (NormUnit)])*($P10=Device_Builds_Table[DeviceType]),0),MATCH('1 Device Builder'!$K$11,Device_Builds_Table[#Headers],0)),"")
2 RACC	50	AX	Pre/Ext Refrigerant Charge (lb/NormUnit) per Device Builder	=IFERROR(INDEX(Device_Builds_Table,MATCH(1,($V10=Device_Builds_Table[TechGroup (NormUnit)])*($W10=Device_Builds_Table[DeviceType]),0),MATCH('1 Device Builder'!$K$11,Device_Builds_Table[#Headers],0)),"")
2 RACC	51	AY	Msr Refrigerant Charge (lb/NormUnit)	=IFERROR(INDEX(Device_Builds_Table,MATCH(1,($I10=Device_Builds_Table[TechGroup (NormUnit)])*($J10=Device_Builds_Table[DeviceType]),0),MATCH('1 Device Builder'!$K$11,Device_Builds_Table[#Headers],0)),"")
2 RACC	52	AZ	Std Refrigerant Charge (lb/NormUnit)	=IFERROR(INDEX(Device_Builds_Table,MATCH(1,($O10=Device_Builds_Table[TechGroup (NormUnit)])*($P10=Device_Builds_Table[DeviceType]),0),MATCH('1 Device Builder'!$K$11,Device_Builds_Table[#Headers],0)),"")
2 RACC	53	BA	Pre/Ext Refrigerant Charge (lb/NormUnit)	=IFERROR(INDEX(Device_Builds_Table,MATCH(1,($V10=Device_Builds_Table[TechGroup (NormUnit)])*($W10=Device_Builds_Table[DeviceType]),0),MATCH('1 Device Builder'!$K$11,Device_Builds_Table[#Headers],0)),"")

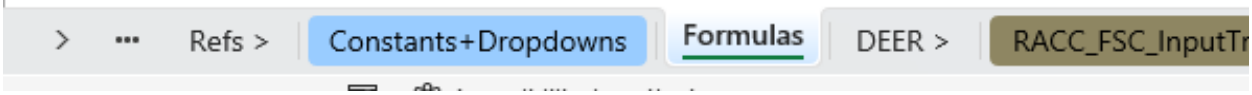


Figure 6: Descriptions of Affected Columns per RACC Technical Guide

Refrigerant Charge

Group	Column	Description
1	Msr refrigerant charge (lb/NormUnit) per Device Builder	Refrigerant charge (lb/NormUnit) per 1 Device Builder worksheet for each device type. If no refrigerant charge was input into the "RefrigCharge Pounds Per NormUnit" (copy from the 0 Refrig Research) column in the Device Builder, this displays as a "0", and a site-specific charge will need to be input into the appropriate custom input refrigerant charge columns.
1	Std refrigerant charge (lb/NormUnit) per Device Builder	
1	Pre/Ext refrigerant charge (lb/NormUnit) per Device Builder	
2	Msr refrigerant charge (lb/NormUnit)	These fields are for custom inputs of the refrigerant charge (lb/NormUnit). For deemed measures, the charge should be defined in the 1 Device Builder worksheet and the contents of these fields should typically not be modified.
2	Std refrigerant charge (lb/NormUnit)	
2	Pre/Ext refrigerant charge (lb/NormUnit)	

Recommendations

The research team recommends the following:

- **'0 Refrig Research' sheet, columns B and C:** Update equipment categories and corresponding common refrigerant
- **'0 Refrig Research' sheet, columns E and F:** Update refrigerant charge values and Normunit
- **'1 Device Builder' sheet, column K:** Update default refrigerant charge values for default device type templates
- **'CARB_RefrigLeaks_DEER' sheet, column B:** Update equipment categories
    - Verify leakage values are accurate (see section CARB_RefrigLeaks_DEER)
- **'CARB_RefrigLeaks_DEER' sheet, column F:** Update refrigerant charge values

Overview

The equipment type and refrigerant charge value updates proposed by the research team directly impact the following sheets:

- '0 Refrig Research' sheet columns B, C, E, and F
- 'CARB_RefrigLeaks_DEER' sheet columns B and F

Indirectly impacted sheets through references, functions, and user-inputs are:

- '1 Device Builder' sheet column J is automatically updated

- ‘1 Device Builder’ sheet column K is user-defined
- ‘2 RACC’ sheet columns AV through BA are automatically updated

The research team recommends updating the refrigerant charge values underlying the RACC Tools to match the residential HVAC equipment categories and the respective refrigerant charge values in Table 1 and Table 2 and commercial HVAC equipment categories and the respective refrigerant charge values in Table 4 and Table 5. If the IOUs decide not to update the categories for the HVAC equipment categories, the refrigerant charge values should be updated to reflect the values in Table 3 and Table 6.

Additional Recommendations

The research team recommends the following updates be made to improve the accuracy of avoided costs calculations:

- Improve the RACC tool to consider difference in charge for different types of refrigerants.
    - The research team found that there is a significant difference in charge values for each equipment type depending on the refrigerant used. Avoided cost calculations will improve by expanding the tool’s capability to consider different charge values for R-410A and R-32/R-454B since many cases will likely involve changing out legacy equipment with newer, low-GWP refrigerant equipment. One possible path to achieve this improvement is to develop a function to auto-generate EUL-IDs on the ‘1 Device Builder’ sheet based on tech type, device type, and refrigerant type. Individual EUL-IDs could be used to reference refrigerant charge values for the respective refrigerant used.
- Simplify references in ‘1 Device Builder’ by moving Column J to ‘0 Refrig Research’ sheet.
    - Currently, the ‘1 Device Builder’ sheet pulls from two sources: the ‘CARB_RefrigLeaks_DEER’ and ‘0 Refrig Research’ sheets. However, ‘0 Refrig Research’ also references the ‘CARB_RefrigLeaks_DEER’ sheet, which may create circular references. The research team recommends congregating all refrigerant charge values and device type inputs into a single sheet, ideally the ‘0 Refrig Research’ sheet. Reducing the ‘1 Device Builder’ sheet’s references to only ‘0 Refrig Research’ opens the potential to use referencing formulas to automatically populate certain columns based on a single source. This would reduce human error when building the ‘1 Device Builder’ sheet which is the baseline reference table that drives RACC Tool results.

Appendix A

Table 1: Recommended Residential HVAC Equipment Categories and the Related Existing Categories

Recommended HVAC Equipment Category	Existing HVAC Equipment Category
Residential Split System AC	Residential Unitary AC
Residential Packaged AC	Residential Unitary AC
Ductless Mini Split AC	Residential Unitary AC
Window AC	Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential
Portable AC	Portable AC
Packaged Terminal AC (PTAC) Units	Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential
Residential Split System HP	Residential Heat Pumps
Residential Packaged HP	Residential Heat Pumps
Ductless Mini Split HP	Residential Heat Pumps
Packaged Terminal HP (PTHP) Units	Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential
Window HP	Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential
Portable HP	Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential
Dehumidifiers	Dehumidifiers

Table 2: Average Refrigerant Charge for Recommended Residential HVAC Equipment Category.

HVAC Equipment Category	Recommended Refrigerant Charge per unit (R-32/R-454B)	Recommended Refrigerant Charge per unit (R-410A)	Existing Refrigerant Charge per unit (R-410A)
Residential Split System AC	2.11 lb/ton	2.46 lb/ton	3.2 lb/ton
Residential Packaged AC	1.98 lb/ton	1.87 lb/ton	3.2 lb/ton
Ductless Mini Split AC	2.50 lb/ton	2.29 lb/ton	3.2 lb/ton
Window AC	0.87 lb/ton	N/A	1.54 lb each
Portable AC	0.96 lb/ton	N/A	1.54 lb each
Packaged Terminal AC (PTAC) Units	1.47 lb/ton	N/A	1.54 lb each
Residential Split System HP	2.57 lb/ton	3.20 lb/ton	3.5 lb/ton
Residential Packaged HP	2.30 lb/ton	3.02 lb/ton	3.5 lb/ton

HVAC Equipment Category	Recommended Refrigerant Charge per unit (R-32/R-454B)	Recommended Refrigerant Charge per unit (R-410A)	Existing Refrigerant Charge per unit (R-410A)
Ductless Mini Split HP	2.39 lb/ton	2.45 lb/ton	3.5 lb/ton
Packaged Terminal HP (PTHP) Units	1.93 lb/ton	2.19 lb/ton	1.54 lb each
Window HP	2.54 lb/ton	N/A	1.54 lb each
Portable HP	0.98 lb/ton	1.41 lb/ton	1.54 lb each
Dehumidifiers	0.61 lb each	0.61 lb each	1.00 lb each

Source: OEM Product Submittals.

Table 3: Recommended Refrigerant Charge for Existing Residential HVAC Equipment Categories

Existing HVAC Equipment Category	Recommended Refrigerant Charge per unit (R-32/R-454B)	Recommended Refrigerant Charge per unit (R-410A)
Residential Unitary AC	2.10 lb/ton	2.26 lb/ton
Residential Heat Pumps	2.46 lb/ton	2.94 lb/ton
Window/Room/Wall AC and Packaged Terminal AC (PTAC) Units, residential	1.20 lb/ton	1.72 lb/ton
Portable AC	0.96 lb/ton	1.41 lb/ton
Dehumidifiers	0.61 lb each	0.61 lb each

Table 4: Recommended Commercial HVAC Equipment Categories and the Related Existing Categories

Recommended HVAC Equipment Category	Existing HVAC Equipment Category
Large Chiller [≥2,000 lbs]	Large Chiller 2,000 lbs. +
Medium Chiller [<2,000 lbs]	Medium Chiller 200-2,000 lbs.
Large Commercial Split AC [≥135 kBtu/h]	Commercial Unitary AC 50-200 lbs., > 135,000 BTUh
Medium Commercial Split AC [135 kBtu/h> Capacity ≥65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh
Small Commercial Split AC [≤65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh
Large Commercial Packaged AC [≥135 kBtu/h]	Commercial Unitary AC 50-200 lbs., > 135,000 BTUh
Medium Commercial Packaged AC [135 kBtu/h> Capacity ≥65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh
Small Commercial Packaged AC [≤65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh

Recommended HVAC Equipment Category	Existing HVAC Equipment Category
Large Commercial Split HP [≥135 kBtu/h]	Commercial Unitary AC 50-200 lbs., > 135,000 BTUh
Medium Commercial Split HP [135 kBtu/h> Capacity ≥65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh
Small Commercial Split HP [≤65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh
Large Commercial Packaged HP [≥135 kBtu/h]	Commercial Unitary AC 50-200 lbs., > 135,000 BTUh
Medium Commercial Packaged HP [135 kBtu/h> Capacity ≥65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh
Small Commercial Packaged HP [≤65 kBtu/h]	Commercial Unitary AC, < 50-lbs., < 135,000 BTUh
PTAC	Window/Room AC and PTAC Units, commercial
PTHP	Window/Room AC and PTAC Units, commercial

Table 5: Refrigerant Charge per Unit for Each Commercial HVAC Type

HVAC Equipment Category	Recommended Refrigerant Charge per unit (R-32/R-454B)	Recommended Refrigerant Charge per unit (R-10A)	Existing Refrigerant Charge per unit
Large Chiller	0.63 lb/ton	1.28 lb/ton	3,978 lb each
Medium Chiller	1.01 lb/ton	1.36 lb/ton	526 lb each
Large Commercial Split AC [≥135 kBtu/h]	1.66 lb/ton	2.02 lb/ton	70 lb each
Medium Commercial Split AC [135 kBtu/h> Capacity ≥65 kBtu/h]	1.32 lb/ton	1.94 lb/ton	3.20 lb/ton
Small Commercial Split AC [≤65 kBtu/h]	1.75 lb/ton	1.76 lb/ton	3.20 lb/ton
Large Commercial Packaged AC [≥135 kBtu/h]	1.11 lb/ton	1.58 lb/ton	70 lb each
Medium Commercial Packaged AC [135 kBtu/h> Capacity ≥65 kBtu/h]	1.03 lb/ton	1.34 lb/ton	3.20 lb/ton
Small Commercial Packaged AC [≤65 kBtu/h]	1.14 lb/ton	2.75 lb/ton	3.20 lb/ton
Large Commercial Split HP [≥135 kBtu/h]	2.19 lb/ton	3.53 lb/ton	70 lb each
Medium Commercial Split HP [135 kBtu/h> Capacity ≥65 kBtu/h]	1.84 lb/ton	3.17 lb/ton	3.5 lb/ton

HVAC Equipment Category	Recommended Refrigerant Charge per unit (R-32/R-454B)	Recommended Refrigerant Charge per unit (R-10A)	Existing Refrigerant Charge per unit
Small Commercial Split HP [≤65 kBtu/h]	2.4 lb/ton	3.14 lb/ton	3.5 lb/ton
Large Commercial Packaged HP [≥135 kBtu/h]	2.09 lb/ton	2.33 lb/ton	70 lb each
Medium Commercial Packaged HP [135 kBtu/h> Capacity ≥65 kBtu/h]	2.13 lb/ton	2.55 lb/ton	3.5 lb/ton
Small Commercial Packaged HP [≤65 kBtu/h]	2.37 lb/ton	N/A	3.5 lb/ton
PTAC	1.47 lb/ton	N/A	1.54 lb each
PTHP	1.93 lb/ton	2.19 lb/ton	1.54 lb each

Table 6: Average Refrigerant Charge Size for Existing Commercial HVAC Equipment Categories

HVAC Equipment Category	Recommended Refrigerant Charge per unit (R-32/R-454B)	Recommended Refrigerant Charge per unit (R-410A)
Large Chiller 2,000 lbs. +	0.63 lb/ton	1.28 lb/ton
Medium Chiller 200-2,000 lbs.	1.01 lb/ton	1.36 lb/ton
Commercial Unitary AC 50-200 lbs., > 135,000 BTUh size	1.54 lb/ton	2.15 lb/ton
Commercial Unitary AC, < 50-lbs., < 135,000 BTUh size (includes smaller "residential-type" central AC and heat pumps)	1.75 lb/ton	2.30 lb/ton
Window/Room AC and PTAC Units, commercial	1.20 lb/ton	1.72 lb/ton