



Domestic Refrigerated Appliances Actions and Assumptions: USA HEM Data

The aim of this document is to detail the actions and assumptions made in interpreting and processing the data specified above during the mapping and benchmarking of domestic refrigerated appliances. It is designed to be read in parallel with the “Summary Overall Mapping and Benchmarking Approach to Domestic Refrigerated Appliances”. Section numbers in each document should align.

1 Overview of the mapping and benchmarking outputs for domestic refrigerated appliances

No data specific actions.

2 The mapping and benchmarking process for domestic refrigerated appliances

2.1 Data Cleaning and Pre-processing

2.1.1 Data cleaning

- a. Removal of all models prior to 1996;
- b. Allocation of model availability for any given year based on the “Year” only. No “model life” is assumed in preceding or following years unless the model is reported separately as appearing in those years;
- c. To revert to “as tested” unit energy consumption, reported chest freezer energy consumption has been multiplied by 1/0.7, and upright and compact freezer energy consumption has been multiplied by 1/0.85. These “adjusted to test” values are only used for benchmarking (i.e. not the mapping report).
- d. Volumes converted to litres (declared x 28.3168466)

In HEM data, model volumes are provided as aggregated values (i.e. a total of fresh and frozen compartments). These compartment volumes have been split into separate fresh and frozen volumes based on a regression analysis conducted by Lawrence Berkley National Laboratories. The values of the slope and intercept for each product type derived from the regression analysis are shown in the table below:

US product type	Slope	Intercept
1	1.0816	0
2	1.0874	0
3	1.1591	0
4	1.2318	0
5	1.1863	0
5A	1.1872	0
6	1.1863	0
7	1.2349	0
11	1.1288	0
12	1.1037	0
13	1.1855	0
14	1.1539	0

Based on the US categories (defined in 2.1.2), the values in this table were used to convert total product volumes to adjusted volumes. Subtracting the total volume from the adjusted volume gives the “freezer adjustment volume”. The “freezer adjustment volume” can then be used to calculate *actual* freezer volume by simple multiplication of the “freezer adjusted volume” by the inverse of the freezer thermodynamic volume adjustment factor, e.g. for the frozen compartment of refrigerator-freezers the multiplication factor would be $1/(1-1.63)$. Fresh compartment volume is then calculated simply as total volume minus freezer volume.

2.1.2 Pre-processing

The pre-processing of data:

- a. Allocation of US, Mapping and Benchmarking and EU product types. This allocation was based on the “style” field. Allocation for the Refrigerators, Freezers and Refrigerator Freezer Data sets as follows:

Style-Defrost Type	USA type ¹	Mapping and Benchmarking Category	EU type	Configuration
bottom freezer no thru-door ice-Not Known	1, 5 or 11, 15	Fridge/Freezer	7	Freezer Bottom
Bottom Freezer-Manual	1 or 11	Fridge/Freezer	7	Freezer Bottom
bottom freezer-Not Known	1, 5 or 11, 15	Fridge/Freezer	7	Freezer Bottom
Bottom-Not Known	1, 5 or 11, 15	Fridge/Freezer	7	Freezer Bottom

¹ Note that a number of units have been allocated two potential “USA types”. In general this is where the unit may be “standard” or “compact”, but there is insufficient data available to differentiate. However, for the purposes of the mapping and benchmarking analysis, both standard and compact units are grouped with no differentiation; therefore the model is assumed to be “standard”. Where more than two types of product are shown, this relates to the potential combinations of products based on a defrost type or the presence of an ice maker which is unknown. In these cases, assumptions default to automatic defrost (which dominates the US market with the exception of refrigerators which are assumed to be manual defrost unless specifically listed otherwise) and no ice maker. These types are shown in bold font in the table.

Style-Defrost Type	USA type ¹	Mapping and Benchmarking Category	EU type	Configuration
Chest Refrigerator-Manual	1 or 11	Refrigerator with Freezer	5	Not Applicable
Fridge Only - Single Door-Manual	1 or 11	Refrigerator with Freezer	5	Not Applicable
Fridge Only - Single Door-Not Known	1 or 11	Refrigerator with Freezer	5	Not Applicable
Fridge/Freezer - Single Door-Manual	1 or 11	Fridge/Freezer	7	Unknown
Fridge/Freezer - Single Door-Not Known	1, 3 or 11, 13	Fridge/Freezer	7	Unknown
Internal Freezer-Manual	1 or 11	Refrigerator with Freezer	5	Not Applicable
Internal Freezer-Not Known	1 or 11	Refrigerator with Freezer	5	Not Applicable
Kitchen Unit-Manual	1 or 11	Fridge/Freezer	7	Unknown
Kitchen Unit-Not Known	1, 5 or 11, 15	Fridge/Freezer	7	Bottom
No freezer-Not Known	1 or 11	Refrigerator with Freezer	1	Not Applicable
Side by Side with no thru-door ice-Not Known	1, 4, 11 or 14	Fridge/Freezer	7	Side-by-Side
Side by Side with thru-door ice-Not Known	7	Fridge/Freezer	7	Side-by-Side
Side by Side-Not Known	1, 4, 7, 11, or 14	Fridge/Freezer	7	Side-by-Side
Side-by-Side w/Ice thru door-Not Known	7	Fridge/Freezer	7	Side-by-Side
Side-by-Side w/o Ice thru door-Not Known	1, 4, 11 or 14	Fridge/Freezer	7	Side-by-Side
Side-by-side with no thru-door ice-Not Known	1, 4, 11 or 14	Fridge/Freezer	7	Side-by-Side
Side-by-side with thru-door ice-Not Known	7	Fridge/Freezer	7	Side-by-Side
Side-by-Side-Manual	1 or 11	Fridge/Freezer	7	Side-by-Side
Side-by-Side-Not Known	1, 4, 7, 11 or 14	Fridge/Freezer	7	Side-by-Side
Side-Not Known	1, 4, 7, 11 or 14	Fridge/Freezer	7	Side-by-Side
Single Door-Manual	1 or 11	Refrigerator with Freezer	5	Not Applicable
Single Door-Not Known	1, 3, 11 or 13	Refrigerator with Freezer	5	Not Applicable
SR-A-Not Known	3 or 13	Refrigerator with Freezer	5	Not Applicable
SR-M-Manual	1 or 11	Refrigerator with Freezer	5	Not Applicable
Top Freezer w/Ice thru door-Not Known	6	Fridge/Freezer	7	Freezer Top
Top Freezer w/o Ice thru door-Manual	1 or 11	Fridge/Freezer	7	Freezer Top
Top Freezer w/o Ice thru door-Not Known	1, 3 or 11, 13	Fridge/Freezer	7	Freezer Top
Top freezer with no thru-door ice-Not Known	1, 3 or 11, 13	Fridge/Freezer	7	Freezer Top
Top freezer with thru-door ice-Not Known	6	Fridge/Freezer	7	Freezer Top
Top Freezer-Manual	1 or 11	Fridge/Freezer	7	Freezer Top
Top Freezer-Not Known	1, 3 or 11, 13	Fridge/Freezer	7	Freezer Top
Top-Manual	1 or 11	Fridge/Freezer	7	Freezer Top
Top-Not Known	1, 3, 11 or 13	Fridge/Freezer	7	Freezer Top
With freezer-Manual	1 or 11	Refrigerator with Freezer	5	Not Applicable
with Freezer-Not Known	1 or 11	Refrigerator with Freezer	5	Not Applicable
Chest - Freezer Only-Manual	10 or 18	Freezer	9	Chest
Chest - Freezer Only-Not Known	10 or 18	Freezer	9	Chest
Chest - Refrigerator Only-Manual	1 or 11	Refrigerator with Freezer	1	Not Applicable
Chest and Other Freezer Only-Manual	10 or 18	Freezer	9	Chest
Chest Freezer-Manual	10 or 18	Freezer	9	Chest
Chest Freezer-Not Known	10 or 18	Freezer	9	Chest

Style-Defrost Type	USA type ¹	Mapping and Benchmarking Category	EU type	Configuration
Chest-Manual	10 or 18	Freezer	9	Chest
Chest-Not Known	10 or 18	Freezer	9	Chest
Freezer Only - Upright-Manual	8 or 16	Freezer	8	Upright
Freezer Only - Upright-Not Known	8, 9 or 16, 17	Freezer	8	Upright
Upright Freezer-Manual	8 or 16	Freezer	8	Upright
Upright Freezer-Not Known	8, 9 or 16, 17	Freezer	8	Upright
Upright-Manual	8 or 16	Freezer	8	Upright
Upright-Not Known	8, 9 or 16, 17	Freezer	8	Upright

- b. Where the configuration of fridge-freezers is unknown, in data processing it is assumed to have the freezers at the bottom. Where freezer configuration is unknown, it is assumed to be upright.
- c. Subsequent to the allocation of product types in the table above, and the volume analysis described in 2.1.1 e., any model that had a freezer volume of less than 14 litres was reallocated to EU type 1 and M&B type "refrigerator only" (this is the equivalent of a US "all refrigerator" unit).
- d. Data with "style" listed as follows were excluded as it was impossible to make reasoned assumptions of product type.

with Freezer-Not Known
Double door-Not Known
Drawer Unit-Not Known
Model Dep.-Manual
Model Dep.-Not Known
N/A-Not Known
no thru-door ice-Not Known
Not Available-Manual
Not Available-Not Known
Wine Chiller-Manual
Wine Chiller-Not Known

- e. Compartments within the various US unit types were allocated to one of mapping and benchmarking compartment categories based on the table below (note this table also gives the assumed test temperatures for each compartment for each product type under US test conditions)

USA Categorisations ²		Fresh Comp Temp	Frozen Comp Temp	Compartment Allocations for Fresh, Frozen and "Other Compartment" Volumes (T=degC)					
				14 > T > 5	5 >= T > 0	T = 0	0 > T => -6	-6 > T => -12	-12 > T => -18
1	Refrigerators with manual defrost	7.22C	-9.44C		Fresh			Frozen	
1	Refrigerator-freezers with manual defrost (irrespective of position of freezer compartment relative to the fresh compartment)	7.22C	-15C		Fresh				Frozen
2	Refrigerator-freezers—partial automatic defrost (irrespective of position of freezer compartment relative to the fresh compartment)	7.22C	-15C		Fresh				Frozen
3	All-refrigerator—automatic defrost	3.33C	-9.44C ³		Fresh			Frozen	
3	Refrigerator-freezers—automatic defrost with top-mounted freezer without through-the-door ice service	7.22C	-15C		Fresh				Frozen
4	Refrigerator-freezers—automatic defrost with side-mounted freezer without through-the-door ice service	7.22C	-15C		Fresh				Frozen
5	Refrigerator-freezers—automatic defrost with bottom-mounted freezer without through-the-door ice service	7.22C	-15C		Fresh				Frozen
6	Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service	7.22C	-15C		Fresh				Frozen
7	Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service	7.22C	-15C		Fresh				Frozen
8	Upright freezers with manual defrost		-17.77C						Frozen
9	Upright freezers with automatic defrost		-17.77C						Frozen
10	Chest freezers and all other freezers except compact freezers		-17.77C						Frozen
11	Compact refrigerators with manual defrost	7.22C	-9.44C		Fresh			Frozen	

² Note that in a number of cases, more than one product type is listed under the same "USA categorisation" number. Refer to the adjacent description to differentiate between products.

³ US regulations do not specify a standardized compartment temperature for the freezer compartment of an "all-refrigerator" units, therefore the actual temperature during tests could vary. However, a nominal temperature of -9.44 has been allocated based on the freezer temperature of "refrigerators" to enable benchmarking with other countries. This is *likely* to lead to a slightly lower unit energy consumption per litre in comparison with other countries.

USA Categorisations ²		Fresh Comp Temp	Frozen Comp Temp	Compartment Allocations for Fresh, Frozen and "Other Compartment" Volumes (T=degC)					
				14 > T > 5	5 >= T > 0	T = 0	0 > T => -6	-6 > T => -12	-12 > T => -18
11	Compact refrigerator-freezers with manual defrost (irrespective of position of freezer compartment relative to the fresh compartment)	7.22C	-15C		Fresh				Frozen
12	Compact refrigerator-freezer—partial automatic defrost (irrespective of position of freezer compartment relative to the fresh compartment)	7.22C	-15C		Fresh				Frozen
13	compact all-refrigerator—automatic defrost	3.33C	-9.44C		Fresh				
13	Compact refrigerator-freezers—automatic defrost with top-mounted freezer	7.22C	-15C		Fresh				Frozen
14	Compact refrigerator-freezers—automatic defrost with side-mounted freezer	7.22C	-15C		Fresh				Frozen
15	Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer	7.22C	-15C		Fresh				Frozen
16	Compact upright freezers with manual defrost		-17.77C						Frozen
17	Compact upright freezers with automatic defrost		-17.77C						Frozen
18	Compact chest freezers		-17.77C						Frozen

2.2 Production of Graphical Mapping Outputs

Local adjusted volume test methodology used:

$$\text{Total Adjusted Volume} = \text{Volume fresh} + n * \text{Volume frozen}$$

Where

USA Classification	n
Refrigerators (excluding all refrigerators)	1.44
Fridge-Freezers	1.63
Freezers	1.73
All Refrigerators	1

2.3 Normalisation

2.3.1 Normalisation Overview

No data specific actions.

2.3.2 Allocation of declared UEC to compartments

The adaptation of the EU methodology used in this analysis requires knowledge of compartment defrost type. It is also possible that we will use information on climate class, whether or not the unit is built in and whether or not the unit has an ice maker in a separate specific piece of benchmarking analysis. These characteristics of each model were allocated based on the “refrig style” and “refrig defrost type” fields.

Allocation for the Refrigerators, Freezers and Refrigerator Freezer Data sets as follows:

Style-Defrost Type	Defrost Type	Built-in	Ice maker
bottom freezer no thru-door ice-Not Known	All Compartments Automatic	Unknown	Unknown
Bottom Freezer-Manual	All Compartments Manual	Unknown	Unknown
bottom freezer-Not Known	All Compartments Automatic	Unknown	Unknown
Bottom-Not Known	All Compartments Automatic	Unknown	Unknown
Chest Refrigerator-Manual	All Compartments Manual	Unknown	Unknown
Fridge Only - Single Door-Manual	All Compartments Manual	Unknown	Unknown
Fridge Only - Single Door-Not Known	All Compartments Manual	Unknown	Unknown
Fridge/Freezer - Single Door-Manual	All Compartments Manual	Unknown	Unknown
Fridge/Freezer - Single Door-Not Known	All Compartments Manual	Unknown	Unknown
Internal Freezer-Manual	All Compartments Manual	Unknown	Unknown
Internal Freezer-Not Known	All Compartments Manual	Unknown	Unknown
Kitchen Unit-Manual	All Compartments Manual	Yes	Unknown
Kitchen Unit-Not Known	All Compartments Automatic	Yes	Unknown
No freezer-Not Known	All Compartments Manual	Unknown	Unknown
Side by Side with no thru-door ice-Not Known	All Compartments Automatic	Unknown	No
Side by Side with thru-door ice-Not Known	All Compartments Automatic	Unknown	Yes
Side by Side-Not Known	All Compartments Automatic	Unknown	Unknown
Side-by-Side w/Ice thru door-Not Known	All Compartments Automatic	Unknown	Yes
Side-by-Side w/o Ice thru door-Not Known	All Compartments Automatic	Unknown	No
Side-by-side with no thru-door ice-Not Known	All Compartments Automatic	Unknown	No
Side-by-side with thru-door ice-Not Known	All Compartments Automatic	Unknown	Yes
Side-by-Side-Manual	All Compartments Manual	Unknown	Unknown
Side-by-Side-Not Known	All Compartments Automatic	Unknown	Unknown
Side-Not Known	All Compartments Automatic	Unknown	Unknown
Single Door-Manual	All Compartments Manual	Unknown	Unknown
Single Door-Not Known	All Compartments Automatic	Unknown	Unknown
SR-A-Not Known	All Compartments Automatic	Unknown	Unknown
SR-M-Manual	All Compartments Manual	Unknown	Unknown

Style-Defrost Type	Defrost Type	Built-in	Ice maker
Top Freezer w/Ice thru door-Not Known	All Compartments Automatic	Unknown	Yes
Top Freezer w/o Ice thru door-Manual	All Compartments Manual	Unknown	No
Top Freezer w/o Ice thru door-Not Known	All Compartments Automatic	Unknown	No
Top freezer with no thru-door ice-Not Known	All Compartments Automatic	Unknown	No
Top freezer with thru-door ice-Not Known	All Compartments Automatic	Unknown	Yes
Top Freezer-Manual	All Compartments Manual	Unknown	Unknown
Top Freezer-Not Known	All Compartments Automatic	Unknown	Unknown
Top-Manual	All Compartments Manual	Unknown	Unknown
Top-Not Known	All Compartments Automatic	Unknown	Unknown
With freezer-Manual	All Compartments Manual	Unknown	Unknown
with Freezer-Not Known	All Compartments Manual	Unknown	Unknown
Chest - Freezer Only-Manual	All Compartments Manual	Unknown	Unknown
Chest - Freezer Only-Not Known	All Compartments Manual	Unknown	Unknown
Chest - Refrgerator Only-Manual	All Compartments Manual	Unknown	Unknown
Chest and Other Freezer Only-Manual	All Compartments Manual	Unknown	Unknown
Chest Freezer-Manual	All Compartments Manual	Unknown	Unknown
Chest Freezer-Not Known	All Compartments Manual	Unknown	Unknown
Chest-Manual	All Compartments Manual	Unknown	Unknown
Chest-Not Known	All Compartments Manual	Unknown	Unknown
Freezer Only - Upright-Manual	All Compartments Manual	Unknown	Unknown
Freezer Only - Upright-Not Known	All Compartments Automatic	Unknown	Unknown
Upright Freezer-Manual	All Compartments Manual	Unknown	Unknown
Upright Freezer-Not Known	All Compartments Automatic	Unknown	Unknown
Upright-Manual	All Compartments Manual	Unknown	Unknown
Upright-Not Known	All Compartments Automatic	Unknown	Unknown

Whilst installation type is not listed in the data for all models, the table below⁴ shows that majority of models in the USA market are freestanding.

Sum of Domestic Unit Shipments Combined DOE Product Class	B, Free Stand	Year		
		2005	2006	2007
1 and 2	B	0.0%	0.1%	0.0%
	F	0.6%	0.3%	0.2%
4	B	0.9%	0.8%	0.7%
	F	0.9%	0.9%	0.7%
5	B	0.0%	0.0%	1.3%
	F	0.0%	0.0%	16.7%
5 and 19	B	1.1%	1.7%	0.0%
	F	2.6%	16.3%	0.0%
7	B	1.0%	1.8%	1.5%
	F	61.7%	55.3%	51.5%
8 and 10	F	11.5%	8.7%	9.2%
	B	0.1%	0.1%	0.2%
9	F	11.5%	9.4%	8.8%
	B	0.3%	0.3%	0.5%
13	F	7.2%	3.6%	2.8%
	B	0.1%	0.1%	0.1%
14 and 15	F	0.0%	0.1%	0.0%
	B	0.0%	0.0%	4.9%
19	F	0.0%	0.0%	4.9%
	B	0.3%	0.4%	0.5%
Wine Cooler	F	0.2%	0.1%	0.4%
	B	0.0%	0.0%	0.0%

Market Share Product Class Data for Built-ins (Selected Product Classes)

⁴ AHAM R-F shipment and efficiency data submission to DOE January 16, 2009

2.3.3 Normalisation of “compartment EC” for test temperature variations and calculation of normalised UEC

The assumed test temperatures for each compartment for each product type are given in the table in section 2.1.2 b).

External test temperature is 32.2°C

2.3.4 Calculation of Normalised UEE

No data specific actions.

2.3.5 Calculation of normalised EEI

No data specific actions.