CHAPTER 7. SHIPMENTS ANALYSIS

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CHAPTER 7. SHIPMENTS ANALYSIS

7.1 INTRODUCTION

Estimates of shipments are a necessary input to national energy savings (NES) and net present value (NPV) calculations. This chapter describes the U.S. Department of Energy's (DOE's) methodology for projecting annual shipments and presents results. The Shipments Model results are driven primarily by available historical shipment data. The Shipments Model is in a Microsoft Excel spreadsheet format embedded in the National Impacts Model spreadsheet that is accessible on the DOE website at http://www1.eere.energy.gov/buildings/appliance_standards/commercial/ashrae_products_docs_meeting.html.

This chapter explains the Shipments Model and its derivation in detail. Section 6.2 discusses the formulation of the model and the data input to the model, and section 6.4 presents the results for the base-case energy conservation standard level scenario and discusses the development of higher standard level scenarios. The energy conservation standards for equipment will set the maximum allowable rated energy consumption for all equipment within an equipment class.

Shipment forecasts were determined for the baseline level and all higher efficiency levels (reflecting potential higher standard levels) for which NES and NPV are required. DOE is considering up to four efficiency levels plus the ASHRAE level for each of the equipment classes.

7.2 FORMULATION OF SHIPMENTS MODEL AND INPUTS

The Shipments Model is a description of equipment stock flows as a function of year and equipment age in the stock. The Department used available historical shipment data to forecast shipments into the future. The Department uses shipments distributions or model availability to allocate shipments into individual product classes.

7.2.1 Historical Shipments

Water and Evaporatively Cooled Products

The Department obtained historical water-cooled commercial air conditioner shipment data from AHRI.[1] While AHRI provided shipments in the categories small, large, and very large, it is important to note that AHRI tracks large units up to 249 kBtu/h, while the federal standards limit the large category to 240 kBtu/h. Throughout this analysis, DOE used AHRI data to represent the large category. Table 7.2.1 shows historical shipments from 1989 through 2009.

Table 7.2.1 Historical Water-Cooled Commercial Air Conditioner Shipments

Year	Small AC (65-134.9 kBtu/h)	Large AC (135-249 kBtu/h)	Very Large AC (250 & Over kBtu/h)
1989	1,437	793	1,622
1990	1,503	779	1,211
1991	1,107	621	908
1992	1,068	537	720
1993	985	520	668
1994	922	504	815
1995	1,121	493	805
1996	1,217	652	1,020
1997	989	522	1,216
1998	795	623	1,886
1999	874	477	898
2000	1,478	1,621	1,170
2001	606	409	762
2002	502	355	1,227
2003	390	287	740
2004	447	291	711
2005	177	188	861
2006	316	278	1,231
2007	359	317	1,231
2008	282	311	1,390
2009	152	182	585

Source: AHRI.

VRF Water Source Heat Pumps

The Department did not have any shipment data available for VRF water source heat pumps. As a result the Department used U.S. Census data showing historical shipments of all water source heat pumps as a starting point.[2] Table 7.2.2 shows historical shipments from 1983 through 2009.

Table 7.2.2 Historical Water Source Heat Pump Shipments

Year	Water Source Heat Pump Shipments (Product Code: 333415E181)
1983	69,280
1984	86,165
1985	119,164
1986	103,970
1987	142,033
1988	149,795
1989	157,080
1990	139,864
1991	111,746
1992	99,236
1993	105,159
1994	99,321
1995	N/A
1996	N/A
1997	112,052
1998	120,080
1999	120,545
2000	133,654
2001	130,351
2002	114,336
2003	123,974
2004	135,769
2005	141,410
2006	202,234
2007	N/A
2008	223,636
2009	180,101

Source: U.S. Census.

Computer Room Air Conditioners

Data on computer room air conditioner shipments in the U.S. were not available. To estimate U.S. shipments, the Department obtained a time series of shipments from 2000 to 2020 in Australia.[3] The Department also looked at several indicators to determine a way to inflate Australian shipments to the U.S. market. These indicators included population, GDP, electricity consumption, and business establishments. These resulted in inflators from 13.2 to 16.8. The Department believes the number of business establishments best serves as a proxy, and therefore used the inflator of 13.2.[4] Table 7.2.3 shows the shipments from the Australia report as well as the shipments inflated to the U.S. market.

Table 7.2.3 Historical Computer Room Air Conditioner Shipments

Year	Computer Room Air Conditioner Shipments (Australian data)	Computer Room Air Conditioner Shipments (United States estimate)
2000	850	11,228
2001	875	11,558
2002	902	11,915
2003	929	12,271
2004	956	12,628
2005	985	13,011
2006	1,014	13,394
2007	1,044	13,790
2008	1,076	14,213
2009	1,107	14,622
2010	1,140	15,058
2011	1,174	15,507
2012	1,209	15,970
2013	1,245	16,445
2014	1,282	16,934
2015	1,320	17,436
2016	1,359	17,951
2017	1,399	18,479
2018	1,440	19,021
2019	1,483	19,589
2020	1,526	20,157

Source: Australia Report, http://www.abs.gov.au, http://factfinder.census.gov.

7.2.2 Projected Shipments

Water and Evaporatively Cooled Products

The Department estimated future shipments using the historical data provided by AHRI. The small and large AC categories show an exponential trend, yielding very few shipments in the future. (Note that the data points for year 2000 were removed as outliers to facilitate identifying historical trends.) The very large AC shipments show no trend, although a linear fit shows a slowly decreasing forecast. Figure 7.2.1 shows the extrapolations, and Table 7.2.4 shows projected shipments for 2010 through 2043.

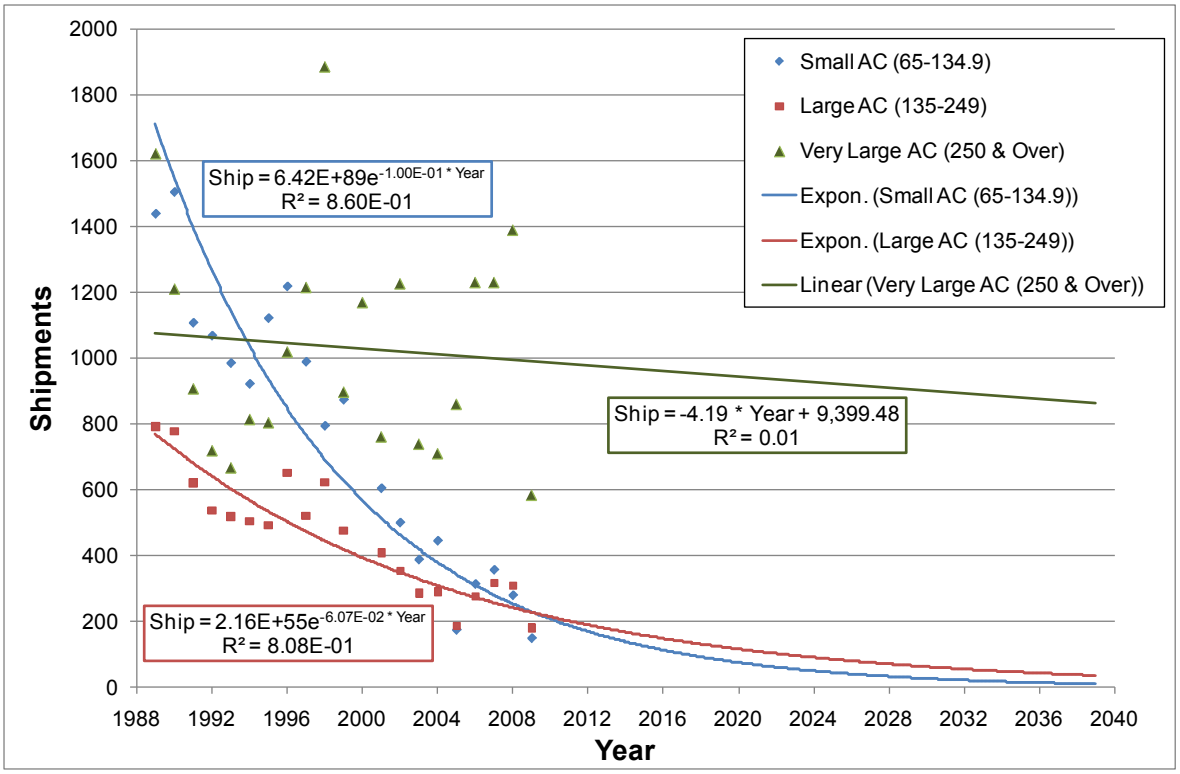

Figure 7.2.1 Trends in Commercial Water-Cooled AC Shipments

Table 7.2.4 Projected Commercial Water-Cooled Air Conditioner Shipments

Year	Small AC (65-134.9 kBtu/h)	Large AC (135-249 kBtu/h)	Very Large AC (350 & Over kBtu/h)
2010	208	215	986
2011	189	203	982
2012	171	191	978
2013	154	179	974
2014	140	169	970
2015	126	159	965
2016	114	150	961
2017	103	141	957
2018	93	132	953
2019	85	125	949
2020	76	117	944
2021	69	110	940
2022	63	104	936
2023	57	98	932
2024	51	92	928
2025	46	87	923
2026	42	81	919
2027	38	77	915
2028	34	72	911
2029	31	68	907
2030	28	64	903
2031	25	60	898
2032	23	57	894
2033	21	53	890
2034	19	50	886
2035	17	47	882
2036	15	44	877
2037	14	42	873
2038	13	39	869
2039	11	37	865
2040	10	35	861
2041	9	33	856
2042	8	31	852
2043	8	29	848

VRF Water Source Heat Pumps

The Department estimated future shipments using the historical data in the U.S. Census. The shipments do not show a strong trend, but the Department used a linear fit. Figure 7.2.2 shows the extrapolations, and Table 7.2.5 shows projected shipments for 2010 through 2042.

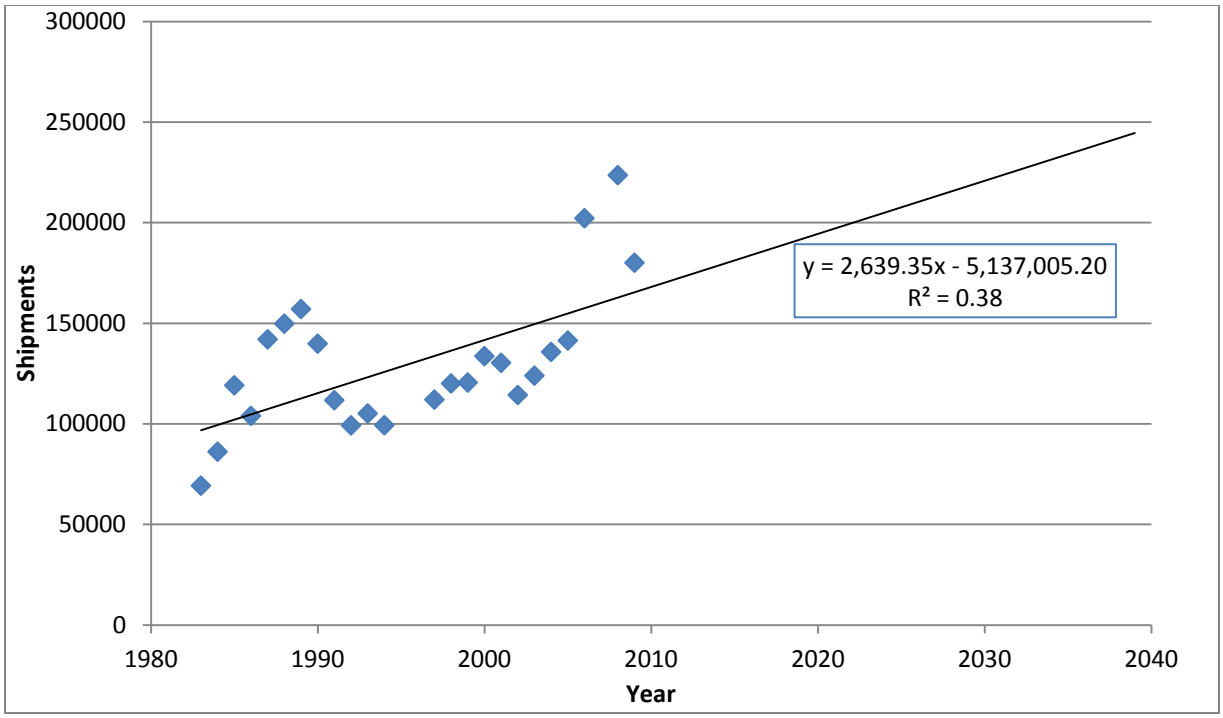

Figure 7.2.2 Projection of Water Source Heat Pump Shipments

Table 7.2.5 Projected Water Source Heat Pump Shipments

Year	Water Source Heat Pump Shipments
2010	168,088
2011	170,728
2012	173,367
2013	176,006
2014	178,646
2015	181,285
2016	183,924
2017	186,564
2018	189,203
2019	191,842
2020	194,482
2021	197,121
2022	199,761
2023	202,400
2024	205,039
2025	207,679
2026	210,318
2027	212,957
2028	215,597
2029	218,236
2030	220,875
2031	223,515
2032	226,154
2033	228,793
2034	231,433
2035	234,072
2036	236,711
2037	239,351
2038	241,990
2039	244,629
2040	247,269
2041	249,908
2042	252,548

Computer Room Air Conditioners

The Department estimated future shipments using the data provided by the Australia report. The data show a strong linear trend that was used to extrapolate shipments into the future past 2020. Figure 7.2.3 shows the extrapolations, and Table 7.2.6 shows projected shipments for 2021 through 2042.

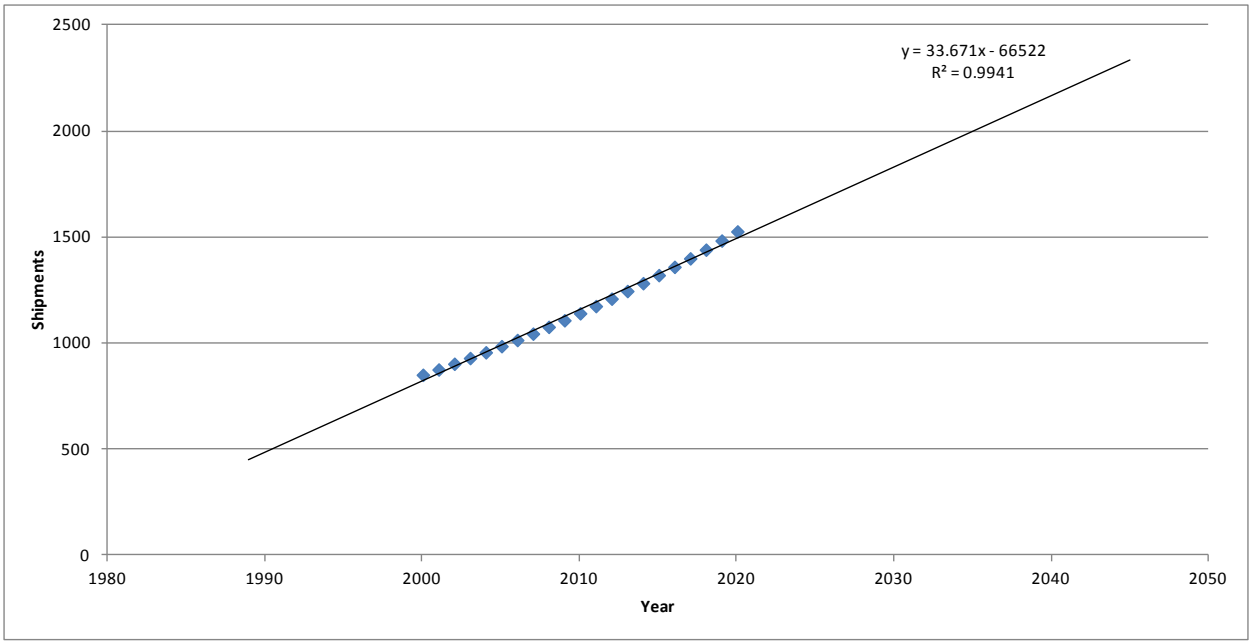

Figure 7.2.3 Projection of Australian Computer Room Air Conditioner Shipments

Table 7.2.6 Projected Computer Room Air Conditioner Shipments (United States)

Year	Computer Room Air Conditioner Shipments
2021	20,171
2022	20,616
2023	21,061
2024	21,506
2025	21,950
2026	22,395
2027	22,840
2028	23,285
2029	23,730
2030	24,174
2031	24,619
2032	25,064
2033	25,509
2034	25,953
2035	26,398
2036	26,843
2037	27,288
2038	27,732
2039	28,177
2040	28,622
2041	29,067
2042	29,511

7.2.3 Product Class Market Shares and Projected Shipments by Product Class

Water and Evaporatively Cooled Products

The Department could not identify data that would allow the shipments provided by AHRI to be separated into products with electrical resistance or no heating, and those with other types of heating. However, the Department believes that most small and large water-cooled equipment do not provide heating, and as a result assigned 90% of shipments in those categories to the no-heating class, and 10% to the other heating class. For very large equipment, the Department believes that most equipment are roof-top units that are combined with gas furnaces, and as a result assigned 10% of very large shipments to the no-heating class and 10% to the other heating class.

The Department identified nine models of very large evaporatively-cooled equipment, but no shipment data were available. For this product class, the Department used the ratio of very large evaporative to water cooled models on the market (9:35) and applied this to the water cooled shipments to estimate evaporatively cooled shipments. The same fraction as for very large water cooled equipment was used to separate units into the heating categories.

VRF Water Source Heat Pumps

DOE undertook research to ascertain the number of models of water source heat pumps in total, and VRF water source heat pumps specifically. DOE used AHRI's Directories of Certified Product Performance for Water-to-Air and Water-to-Water Heat Pumps (excluding groundwater loop and ground loop) and VRF Multi-Split Water-to-Air Heat Pumps.[5] DOE used the ratio of VRF water source heat pump >135,000 Btu/h models to all water source heat pump models on the market (164:4277) to estimate VRF water source heat pump shipments. DOE also used the number of VRF water source heat pumps >135,000 Btu/h with and without heat recovery (58 and 106, respectively) to allocate shipments into the two product classes.

Computer Room Air Conditioners

DOE allocated overall shipments into product classes using a two-step process. First, DOE used Australian market shares to allocate shipments to six broad product classes (Table 7.2.7). Although it was not clear from the Australia report how glycol-cooled units were included, the Department assumed they were part of the water-cooled product class. The Department then used its database of computer room air conditioner models available in the U.S. to further disaggregate shipments into water and glycol cooled product classes with and without fluid economizers (Table 7.2.8).

Table 7.2.7 Computer Room Air Conditioners: Market Share by Product Class (Australia)

Product Class	Market Share
Air-Cooled <65 kBtu/h	4%
Air-Cooled ≥65 - <240 kBtu/h	46%
Air-Cooled ≥240 kBtu/h	10%
Water-Cooled <65 kBtu/h	2%
Water-Cooled ≥65 - <240 kBtu/h	30%
Water-Cooled ≥240 kBtu/h	8%
TOTAL	**100.00%**

Table 7.2.8 Computer Room Air Conditioners: Market Share by Product Class (US)

Product Class	Water-Cooled	Water-Cooled with Fluid Economizer	Glycol-Cooled	Glycol -Cooled with Fluid Economizer	TOTAL
Water-Cooled <65 kBtu/h	29%	18%	27%	27%	**101.00%**
Water-Cooled ≥65 - <240 kBtu/h	25%	21%	25%	29%	**100.00%**
Water-Cooled ≥240 kBtu/h	34%	13%	28%	25%	**100.00%**

7.3 RESULTS

As equipment purchase price increases with lower energy consumption levels, a drop in shipments could be expected relative to the base case. However, DOE has no information with which to calibrate such a relationship. Therefore, for the Notice of Proposed Rulemaking analysis, DOE presumes that the shipments do not change in response to higher efficiency levels being considered as possible standard levels.

Water and Evaporatively Cooled Equipment

DOE used two shipment scenarios in the analysis of water and evaporatively cooled equipment: one using the trends identified from historical data, and another with future shipments fixed to the 2009 value. Table 7.3.1 shows the shipments used for all the product classes in this analysis using the historical shipment scenario. This is based on the AHRI historical data, the forecasted shipments, and the attribution of the shipments to the specific product classes. Table 7.3.2 shows shipments in 2009 as well as the cumulative shipments under the constant shipments scenario.

Table 7.3.1 Water and Evaporatively Cooled Equipment Shipments: Historical Trend

Year	Small Water E/N 65-135	Small Water O 65-135	Large Water E/N 135-240	Large Water O 135-240	VL Water E/N 240-760	VL Water O 240-760	VL Evap E/N 240-760	VL Evap O 240-760
2013	139	15	-	-	-	-	-	-
2014	126	14	152	17	97	873	25	224
2015	113	13	143	16	97	868	25	223
2016	103	11	135	15	96	865	25	222
2017	93	10	127	14	96	861	25	221
2018	84	9	119	13	95	858	24	221
2019	77	8	113	12	95	854	24	220
2020	68	8	105	12	94	850	24	219
2021	62	7	99	11	94	846	24	218
2022	57	6	94	10	94	842	24	217
2023	51	6	88	10	93	839	24	216
2024	46	5	83	9	93	835	24	215
2025	41	5	78	9	92	831	24	214
2026	38	4	73	8	92	827	24	213
2027	34	4	69	8	92	823	24	212
2028	31	3	65	7	91	820	23	211
2029	28	3	61	7	91	816	23	210
2030	25	3	58	6	90	813	23	209
2031	23	2	54	6	90	808	23	208
2032	21	2	51	6	89	805	23	207
2033	19	2	48	5	89	801	23	206
2034	17	2	45	5	89	797	23	205
2035	15	2	42	5	88	794	23	204
2036	14	1	40	4	88	789	23	203
2037	13	1	38	4	87	786	22	202
2038	12	1	35	4	87	782	22	201
2039	10	1	33	4	87	778	22	200
2040	9	1	32	3	86	775	22	199
2041	8	1	30	3	86	770	22	198
2042	7	1	28	3	85	767	22	197
2043	-	-	26	3	85	763	22	196
Cumulative	1384	151	2164	239	2728	24536	701	6311

Table 7.3.2 Water and Evaporatively Cooled Equipment Shipments: Shipments Fixed at 2009 Level

Year	Small Water E/N 65-135	Small Water O 65-135	Large Water E/N 135-240	Large Water O 135-240	VL Water E/N 240-760	VL Water O 240-760	VL Evap E/N 240-760	VL Evap O 240-760
2009	137	15	164	18	59	526	15	135
Cumulative (2013 to 2042 or 2014 to 2043)	4,110	450	4,920	540	1,770	15,780	450	4,050

VRF Water Source Heat Pumps

Table 7.3.3 shows the shipments used for both the VRF water source heat pump product classes in this analysis. This is based on the US Census historical data, the forecasted shipments, and the attribution of the shipments to the specific product classes.

Table 7.3.3 VRF Water Source Heat Pump Shipments

Year	Without Heat Recovery	With Heat Recovery
2013	4,417	2,417
2014	4,483	2,453
2015	4,549	2,489
2016	4,616	2,525
2017	4,682	2,562
2018	4,748	2,598
2019	4,814	2,634
2020	4,880	2,670
2021	4,947	2,707
2022	5,013	2,743
2023	5,079	2,779
2024	5,145	2,815
2025	5,212	2,852
2026	5,278	2,888
2027	5,344	2,924
2028	5,410	2,960
2029	5,477	2,997
2030	5,543	3,033
2031	5,609	3,069
2032	5,675	3,105
2033	5,741	3,142
2034	5,808	3,178
2035	5,874	3,214
2036	5,940	3,250
2037	6,006	3,287
2038	6,073	3,323
2039	6,139	3,359
2040	6,205	3,395
2041	6,271	3,432
2042	6,338	3,468
Cumulative	161,316	88,268

Computer Room Air Conditioners

Table 7.3.4 shows the shipments used all the computer room air conditioner product classes in this analysis. This is based on the Australian data, the inflation of Australian data to the US market, the forecasted shipments, and the attribution of the shipments to the specific product classes.

Table 7.3.4 Computer Room Air Conditioner Shipments

Year	Air-cooled <65	Air-Cooled 65-240	Air-cooled >240	Water-cooled <65	Water-cooled 65-240	Water-cooled >240	Water-cooled <65 FE	Water-cooled 65-240 FE	Water-cooled >240 FE	Glycol cooled <65	Glycol cooled 65-240	Glycol cooled >240	Glycol cooled <65 FE	Glycol cooled 65-240 FE	Glycol cooled >240 FE
2012	671	-	-	74	-	-	46	-	-	69	-	-	69	-	-
2013	691	7,499	1,677	76	1,233	470	47	1,036	180	71	1,233	387	71	1,431	345
2014	711	7,722	1,727	79	1,270	484	49	1,067	185	73	1,270	398	73	1,473	356
2015	732	7,951	1,778	81	1,308	498	50	1,098	190	75	1,308	410	75	1,517	366
2016	754	8,186	1,831	83	1,346	513	52	1,131	196	78	1,346	422	78	1,562	377
2017	776	8,427	1,885	86	1,386	528	53	1,164	202	80	1,386	435	80	1,608	388
2018	799	8,674	1,940	88	1,427	543	55	1,198	208	82	1,427	447	82	1,655	399
2019	823	8,933	1,998	91	1,469	559	56	1,234	214	85	1,469	461	85	1,704	411
2020	847	9,192	2,056	94	1,512	576	58	1,270	220	87	1,512	474	87	1,754	423
2021	847	9,198	2,057	94	1,513	576	58	1,271	220	87	1,513	474	87	1,755	424
2022	866	9,401	2,103	96	1,546	589	59	1,299	225	89	1,546	485	89	1,794	433
2023	885	9,604	2,148	98	1,580	602	61	1,327	230	91	1,580	495	91	1,832	442
2024	903	9,807	2,194	100	1,613	614	62	1,355	235	93	1,613	506	93	1,871	452
2025	922	10,009	2,239	102	1,646	627	63	1,383	240	95	1,646	516	95	1,910	461
2026	941	10,212	2,284	104	1,680	640	64	1,411	245	97	1,680	527	97	1,948	470
2027	959	10,415	2,330	106	1,713	652	66	1,439	249	99	1,713	537	99	1,987	480
2028	978	10,618	2,375	108	1,746	665	67	1,467	254	101	1,746	548	101	2,026	489
2029	997	10,821	2,420	110	1,780	678	68	1,495	259	103	1,780	558	103	2,064	498
2030	1,015	11,023	2,466	112	1,813	690	70	1,523	264	104	1,813	569	104	2,103	508
2031	1,034	11,226	2,511	114	1,846	703	71	1,551	269	106	1,846	579	106	2,142	517
2032	1,053	11,429	2,557	116	1,880	716	72	1,579	274	108	1,880	590	108	2,181	526
2033	1,071	11,632	2,602	118	1,913	729	73	1,607	279	110	1,913	600	110	2,219	536
2034	1,090	11,835	2,647	120	1,947	741	75	1,635	283	112	1,947	610	112	2,258	545
2035	1,109	12,038	2,693	122	1,980	754	76	1,663	288	114	1,980	621	114	2,297	554
2036	1,127	12,240	2,738	125	2,013	767	77	1,691	293	116	2,013	631	116	2,335	564
2037	1,146	12,443	2,783	127	2,047	779	79	1,719	298	118	2,047	642	118	2,374	573
2038	1,165	12,646	2,829	129	2,080	792	80	1,747	303	120	2,080	652	120	2,413	582
2039	1,183	12,849	2,874	131	2,113	805	81	1,775	308	122	2,113	663	122	2,451	592
2040	1,202	13,052	2,919	133	2,147	817	82	1,803	313	124	2,147	673	124	2,490	601
2041	1,221	13,254	2,965	135	2,180	830	84	1,831	317	126	2,180	684	126	2,529	610
2042	-	13,457	3,010	-	2,213	843	-	1,859	322	-	2,213	694	-	2,567	620
Cumulative	28,518	315,793	70,636	3,152	51,940	19,780	1,954	43,628	7,563	2,935	51,940	16,288	2,935	60,250	14,542

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