

# Summary of CANDU Fuel Burnups and Power Ratings

**NWMO-TR-2025-11**

**December 2025**

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Kinectrics

**nwmo**

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## ABSTRACT

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### Abstract

The irradiation history of CANDU fuel bundles is summarized in this report over the existing used CANDU fuel bundle population. Burnups, average bundle powers, maximum bundle powers and maximum linear element powers for fuel bundles that have been discharged from Ontario Power Generation, Bruce Power, Hydro-Quebec, and New Brunswick Power reactors were extracted from available digital archives. Data was not readily available in digital format for early Pickering A, Point Lepreau and Gentilly-2 operation and estimates of the distribution of the burnup and linear power ratings were prepared and included as part of the overall population statistics. This report serves as an update to NWMO-TR-2019-04, with newly extracted data since that report and the addition of average bundle power calculations. Estimated bundle power distributions were determined from the linear power rating distributions. The known and estimate data were combined, statistically analyzed, and plotted as frequency histograms.

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## 1. INTRODUCTION

Used fuel burnups and power ratings are important parameters for deep geological disposal of spent fuel. They largely determine the inventory of radionuclides present in the fuel as well as the fraction of fission products that are able to migrate to the fuel gap and grain boundaries.

In 2006, an Ontario Power Generation report was issued that summarized the burnups and maximum (bundle) power ratings for CANDU fuel discharged from the Darlington, Pickering A & B, and Bruce A & B reactors during the period from 1970 to 2006 (Wilk & Cantello, 2006). This report was subsequently updated in 2013 (Wilk, 2013) with information for Hydro-Quebec (Gentilly-2) and New Brunswick Power (Point Lepreau) stations. The discharged fuel bundle data for each station's reactors were combined and plotted as frequency histograms of burnup and maximum power rating for the time periods 1970-1979, 1980-1989, 1990-1999, 2000-2010 and 2010-2012, where data was available. Also presented were the maximum, median, 90<sup>th</sup>, 95<sup>th</sup> and 99<sup>th</sup> percentile burnups and maximum power ratings for each station (for each time period), as well as the total number of bundles discharged from each reactor over the entire period (1970-2012). In 2021, NWMO issued a report (Lampman, 2021) which included data from 2012-2018 for those reactors and constructed estimates where data was not readily available in electronic format to be incorporated into the frequency histograms.

The purpose of this project is to update the existing 2021 NWMO report by including more recent data for those reactors (2018-2025). Additionally, the average bundle power was calculated for bundles where power data was available.

## 2. DATA EXTRACTION

The majority of the used fuel is from Ontario Power Generation (OPG) and Bruce Power (BP) reactors. For these reactors, fuel bundle data were extracted via Unix and FORTRAN scripts from SORO (Wilk, 2005) digital archives on the Kinectrics Unix LAN. The database extracted bundle information up to the end of 2024, except for Pickering A where it included some small additional bundles discharged in early 2025 as part of the final shutdown of this station.

The SORO database includes inter-unit recycling, whereby bundles discharged from one reactor are inserted into another one, and then discharged from that second reactor. Such bundles appear twice in SORO discharged bundle records, and scans of the records (such as for this report) incorrectly double-count such bundles unless some complex data filtering is applied. Considering the relatively small number of such bundles (see Table 1) in comparison with the total number discharged from a station, the programming effort required to perform the required filtering was considered unwarranted. In particular, by far the greatest number of inter-unit recycled bundles occurred for Bruce A, where 1,504 bundles were inter-unit recycled, corresponding to ~0.2% of the Bruce A bundles. For the other stations, the amount was about 0.01% or less. Consequently, these records include a very small double-counting of such inter-unit recycled bundles.

The bundle data provided by Hydro-Québec for Gentilly-2 were contained in several files, each spanning a different period of operating history, with separate files for burnups and bundle serial numbers, bundle powers, and fuelling history. Exit burnups were available for the entire operational period from 1983 to discharge of final bundles after shutdown in September 2013.

However, the maximum experienced bundle powers were available only for the reactor operating period from 2900.2 full power days (October 1993) to unit shutdown at 8261.0 full power days (December 2012). A Python script was prepared to track bundle movements (by serial number) and to extract the exit burnups and discharge dates for all bundles. Where possible, the maximum bundle powers and average bundle powers for the discharged bundles were also collected for bundles with a complete power history. Since the burnups had been provided in units of MWh/bundle, they were converted to MWh/kgU by dividing by the mean mass of uranium per bundle (19.2 kg, as provided by Hydro-Quebec staff).

The data files provided by New Brunswick Power for the Point Lepreau reactor included histories of bundle burnups, bundle powers, refuelling operations and a list of bundle serial numbers correlated to discharge channel/position and date. A Python script was prepared to read the data and extract exit burnups, maximum experienced bundle power, average bundle power and discharge date for all discharged bundles for which a complete history was available. The available digital information for Point Lepreau covers the period from January 1994 to December 2024.

### 3. ESTIMATION OF HISTORICAL DATA

Fuel bundle data was not readily available in electronic format during the following periods for Pickering A units, Point Lepreau and Gentilly-2:

- Unit Commissioning (starting 1970) to December 1986 for all Pickering A units,
- Unit Commissioning (February 1983) to December 1993 for Point Lepreau, and
- Unit Commissioning (October 1983) to October 1993 for bundle power data at Gentilly-2.

Through discussion with staff at the Nuclear Generating Stations, samples of the archived, non-electronic-format bundle records were collected and examined to determine how to convert these records to electronic format for analysis. Information loss using automated conversion methods was too significant to reconstruct bundle data information of sufficient quality.

However, it was possible to reasonably estimate the frequency histograms working with industry experts knowledgeable in Pickering A, Point Lepreau and Gentilly-2 operations and reviewing the available data and operations at each Nuclear Generating Station. It was concluded that there was little value in proceeding with extracting data from non-electronic records as it was found that estimation based on similar data was acceptable for population statistics.

Estimates for the historical data where no electronic records exist were generated in the 2021 update to this database (Lampman, 2021). The process to construct the estimates started with a review of year-to-year variations in the frequency histograms. It was found that the shape, or distribution, of the yearly histograms does not significantly change, as is expected as reactor fuelling practises are consistent. However, occasionally there is a minor change in the distributions and expert panel reviews were held for each Nuclear Generating Station with industry experts and station staff knowledgeable in the station's operating history to identify the cause of the changes. By reviewing the entire operating history of the Nuclear Generating Station, and correlating changes in the distributions to operating changes, the expert panel reviews established the technical basis to create an estimate of the frequency histograms for the periods for which data was not readily obtainable. These estimates were combined with the known histograms from electronic data to give the combined frequency histograms representing the entire operating period of the Nuclear Generating Stations given in this report.

This report includes the estimated distributions into the summary statistics that are calculated for the discharge burnup, maximum bundle power and maximum linear power rating data. This includes incorporating the estimates into the statistics given by decades. To include the estimates into the decade statistics, it was assumed that the estimated distributions did not change in each decade and the total number of estimated bundles discharged in each decade was scaled by the number of operation years of the station in each decade. Estimates for the average bundle power is not calculated as the distribution of this metric has not been determined.

#### 4. DATA ANALYSIS

All data were analyzed by a Python script that calculated some basic statistical parameters and generated histograms of exit burnup and maximum power rating.

Table 1 shows, for each station, the number of discharged bundles from electronic records that contributed to the known fuel bundle information. Table 2 shows the mean, median, 90<sup>th</sup> percentile, 95<sup>th</sup> percentile, 99<sup>th</sup> percentile and maximum discharge burnups grouped by station and decade. Table 3 gives a breakdown of the known bundle discharge burnups into higher burnup intervals.

Table 4 provides the mean, maximum and selected percentiles for the maximum linear power rating distributions for all bundles (known plus estimated bundle data) discharged from each station. Table 5 shows the same information for maximum bundle powers and Table 6 gives the same information for average bundle powers.

Aggregated values for the above metrics are given in Tables 7 through 11.

Figures 1-8 show the histograms of aggregated bundle discharge burnup for all stations, as well as bundle discharge burnup for each station. These histograms account for the known and estimated bundles. Figures 9 and 10 show the histograms for maximum linear power rating and maximum bundle power aggregated over all stations, respectively, and account for the known and estimated bundle data. Figure 11 shows the histogram for average bundle power aggregated over all stations and only accounts for the known bundle data.

Figures 12-19 are heat maps illustrating the correlation between average bundle power and discharge burnup for the known bundle data.

It should also be noted that all of the above discharge burnups and bundle power ratings are predicted (simulated) quantities based on various theoretical models and calculational tools. As such, they possess inherent uncertainties and no attempt has been made here to account for these uncertainties. However, the uncertainties are not expected to significantly affect the results of the population statistics.

**Table 1: Known Discharged Bundles Summary Data**

<b>Reactor</b>	<b>Start Date (yyyymmdd)</b>	<b>End Date (yyyymmdd)</b>	<b>Bundles Discharged</b>	<b>Inter-unit Recycled Bundles</b>
Bruce A Unit 1	19770821	20241231	151,503	1,443
Bruce A Unit 2	19770210	20241231	139,367	0
Bruce A Unit 3	19780507	20230330	187,119	13
Bruce A Unit 4	19790510	20241231	182,167	48
		Total	660,156	1,504
Bruce B Unit 5	19850708	20241231	220,035	4
Bruce B Unit 6	19840913	20241231	202,599	0
Bruce B Unit 7	19860625	20241231	213,490	32
Bruce B Unit 8	19870730	20241231	207,691	36
		Total	843,815	72
		<b>BP Total</b>	<b>1,503,971</b>	
Pickering A Unit 1	19880524	20250228	76,805	0
Pickering A Unit 2	19890611	20070528	24,488	0
Pickering A Unit 3	19870106	20081013	30,844	0
Pickering A Unit 4	19870107	20241224	77,146	0
		Total	209,283	0
Pickering B Unit 5	19830814	20241231	124,776	0
Pickering B Unit 6	19840607	20241231	127,778	0
Pickering B Unit 7	19850531	20241231	121,040	0
Pickering B Unit 8	19860805	20241230	114,829	0
		Total	488,423	0
Darlington Unit 1	19910505	20241011	167,409	8
Darlington Unit 2	19901031	20241231	162,833	0
Darlington Unit 3	19930407	20241231	162,270	65
Darlington Unit 4	19930926	20230904	168,417	0
		Total	660,929	73
		<b>OPG Total</b>	<b>1,358,635</b>	
Gentilly-2	19831121	20130930	129,928	0
		<b>HQ Total</b>	<b>129,928</b>	
Point Lepreau	19940104	20241228	117,980	0
		<b>NBP Total</b>	<b>117,980</b>	
		<b>Overall Total</b>	<b>3,110,514</b>	

**Table 2: Decade Bundle Burnup Summary Statistics (Known + Estimated)<sup>1</sup>**

Station	Decade	Burnup (MWh/kgU)					
		Mean	Percentile			Max	
			50th	90th	95th	99th	
Bruce A	1970's	139	133	231	248	279	355
	1980's	193	203	259	270	296	706
	1990's	185	192	264	274	297	657
	2000's	198	206	275	284	304	384
	2010's	203	210	271	279	293	425
	2020's	202	208	270	277	290	334
Bruce B	1980's	177	179	216	231	270	506
	1990's	189	190	217	226	253	403
	2000's	187	190	220	227	246	448
	2010's	184	188	219	226	242	473
	2020's	171	177	212	220	237	306
Pickering A	1970's	220	210	277	288	303	400
	1980's	211	207	272	285	303	518
	1990's	201	202	265	285	318	521
	2000's	186	198	266	279	295	438
	2010's	219	210	277	289	304	415
	2020's	200	201	271	284	302	472
Pickering B	1980's	181	188	218	228	249	479
	1990's	195	193	225	236	259	595
	2000's	191	190	226	235	253	548
	2010's	196	195	231	240	257	465
	2020's	193	192	229	240	258	463
Darlington	1990's	191	195	230	241	262	320
	2000's	204	205	240	250	268	390
	2010's	199	201	239	249	268	349
	2020's	170	185	227	237	259	405
Gentilly-2	1980's	172	175	215	229	250	291
	1990's	179	177	213	227	245	346
	2000's	175	171	208	224	241	321
	2010's	149	162	197	214	234	268
Point Lepreau	1980's	174	172	212	228	249	330
	1990's	173	171	212	228	249	330
	2000's	166	169	210	227	248	321
	2010's	160	161	200	219	244	313
	2020's	159	156	194	213	236	303

<sup>1</sup> Highlighted rows include estimated bundle statistics.

**Table 3: Discharge Burnup Intervals by Decade (Known)**

Station	Decade	Number of bundles in burnup interval (upper bound inclusive)									
		0-220	220-300	300-350	350-400	400-450	450-500	500-550	550-600	600-650	650-700
Bruce A	1970's	32,772	5,260	78	2						
	1980's	119,894	73,915	1,190	197	99	65	29	21	10	5
	1990's	76,216	45,349	769	120	59	43	20	9	2	1
	2000's	29,581	22,143	675	15						
	2010's	84,025	70,139	656	7	4					
	2020's	53,123	43,484	177							
Bruce B	1980's	81,537	6,920	170	26	14	9	4			
	1990's	190,314	16,381	206	27	2					
	2000's	193,554	20,295	168	35	7					
	2010's	210,716	20,550	119	15	4	2				
	2020's	97,758	4,980	2							
Pickering A	1970's										
	1980's	21,482	4,501	118	19	9	8	1			
	1990's	46,048	17,372	1,451	125	16	2	3			
	2000's	24,122	9,030	150	14	8					
	2010's	31,269	19,782	812	21	8					
	2020's	22,023	10,462	392	25	8	2				
Pickering B	1980's	62,709	5,937	17	11	2	4				
	1990's	102,413	15,645	109	37	7	3	2	4		
	2000's	100,946	16,373	98	23	9	2	4			
	2010's	99,093	22,869	111	31	10	2				
	2020's	51,269	10,632	34	11	4	2				
Darlington	1990's	122,595	26,250	38							
	2000's	153,918	63,912	68	7						
	2010's	152,863	55,476	40							
	2020's	73,005	12,708	37	11	1					
Gentilly-2	1980's	24,105	2,008								
	1990's	41,487	3,272	12							
	2000's	41,083	2,810	7							
	2010's	14,593	551								
Point Lepreau	1980's										
	1990's	21,459	1,690	7							
	2000's	38,167	2,736	9							
	2010's	31,589	1,597	6							
	2020's	19,968	750	2							

**Table 4: Decade Maximum Linear Power Rating Summary Statistics (Known + Estimated)**

Station	Decade	Linear Power Rating (kW/m)					
		Mean	Percentile				Max
			50th	90th	95th	99th	
Bruce A	1970's	33.7	35.3	47.1	49.1	51.7	55.8
	1980's	42.1	44.8	53.3	54.8	57.2	63.7
	1990's	36.5	38.5	50.6	52.7	55.0	58.9
	2000's	40.4	43.2	52.1	53.0	54.3	56.7
	2010's	40.9	44.2	51.4	52.2	53.5	56.3
	2020's	42.2	45.5	52.3	53.0	54.2	56.1
Bruce B	1980's	40.3	42.7	46.6	47.5	49.1	52.8
	1990's	39.2	40.7	45.5	46.6	48.3	51.6
	2000's	38.3	40.1	43.1	43.9	45.2	48.0
	2010's	39.8	41.8	44.8	45.4	46.5	49.6
	2020's	39.3	41.6	44.9	45.6	46.6	48.9
Pickering A	1970's	43.6	45.9	52.3	53.5	55.2	57.0
	1980's	42.1	44.8	51.9	53.2	55.0	60.9
	1990's	42.4	45.2	52.9	54.2	56.0	62.2
	2000's	41.5	44.9	52.1	53.4	54.8	57.8
	2010's	43.7	46.0	52.4	53.5	54.9	56.6
	2020's	42.9	45.9	52.5	53.7	55.0	56.9
Pickering B	1980's	42.4	45.0	51.1	52.5	54.9	60.6
	1990's	43.3	45.5	51.0	52.2	54.4	59.7
	2000's	42.5	44.9	49.6	50.5	52.0	55.6
	2010's	42.6	45.0	49.8	50.8	52.4	56.2
	2020's	42.5	45.0	49.4	50.3	51.8	55.4
Darlington	1990's	40.6	42.9	46.7	47.6	49.0	52.2
	2000's	42.2	44.5	48.2	48.9	50.1	52.4
	2010's	42.4	44.9	48.6	49.3	50.3	52.6
	2020's	40.1	43.5	48.1	48.9	50.1	52.3
Gentilly-2	1980's	40.4	42.0	50.1	51.6	53.8	56.2
	1990's	40.6	42.5	50.0	51.5	53.5	56.2
	2000's	39.6	41.1	49.4	50.8	53.0	55.5
	2010's	35.5	37.3	46.7	48.2	50.5	52.7
Point Lepreau	1980's	39.8	41.3	49.4	50.7	52.7	54.8
	1990's	40.0	41.7	49.3	50.6	52.4	54.8
	2000's	36.9	38.3	46.6	47.9	50.0	53.8
	2010's	39.0	40.4	49.0	50.4	52.2	54.6
	2020's	39.5	40.7	49.5	51.0	52.5	54.9

**Table 5: Decade Maximum Bundle Power Summary Statistics (Known + Estimated)**

Station	Decade	Bundle Power (kW)					
		Mean	Percentile				Max
			50th	90th	95th	99th	
Bruce A	1970's	528	554	739	771	811	876
	1980's	660	703	836	861	898	1000
	1990's	573	604	793	828	864	924
	2000's	633	678	818	832	853	890
	2010's	643	695	808	821	841	883
	2020's	663	715	822	835	853	882
Bruce B	1980's	633	670	732	745	771	828
	1990's	617	640	715	731	757	810
	2000's	605	634	684	695	718	773
	2010's	627	657	705	716	735	781
	2020's	619	655	706	717	734	770
Pickering A	1970's	530	559	637	652	672	690
	1980's	513	546	632	648	670	741
	1990's	517	551	644	660	682	757
	2000's	505	546	635	650	668	703
	2010's	532	560	639	652	669	690
	2020's	523	559	640	653	670	693
Pickering B	1980's	516	548	623	639	669	738
	1990's	527	554	621	636	662	727
	2000's	517	547	603	615	633	678
	2010's	519	549	607	619	638	684
	2020's	517	548	602	613	631	674
Darlington	1990's	638	674	735	749	772	835
	2000's	668	704	765	778	800	843
	2010's	678	718	776	788	806	843
	2020's	639	694	768	781	800	836
Gentilly-2	1980's	634	660	787	810	843	880
	1990's	637	667	785	808	839	880
	2000's	621	645	775	798	832	871
	2010's	557	585	732	756	793	827
Point Lepreau	1980's	625	647	774	796	826	860
	1990's	627	653	773	794	822	860
	2000's	579	602	731	753	785	844
	2010's	612	633	769	791	819	857
	2020's	619	638	777	800	824	862

**Table 6: Decade Average Bundle Power Summary Statistics (Known)**

Station	Decade	Bundle Power (kW)					
		Mean	Percentile				Max
			50th	90th	95th	99th	
Bruce A	1970's	379	391	551	601	672	769
	1980's	400	430	540	597	705	841
	1990's	348	363	483	505	578	800
	2000's	400	426	516	546	606	832
	2010's	406	438	501	543	600	771
	2020's	425	454	515	569	623	742
Bruce B	1980's	432	468	557	576	623	722
	1990's	420	451	531	547	569	701
	2000's	420	456	512	522	550	691
	2010's	448	470	528	537	557	703
	2020's	450	473	532	542	615	684
Pickering A	1970's						
	1980's	379	407	517	533	561	613
	1990's	355	376	446	471	510	599
	2000's	350	371	438	470	513	580
	2010's	363	380	428	444	489	564
	2020's	366	386	441	470	516	562
Pickering B	1980's	383	405	477	499	544	600
	1990's	379	399	457	465	478	610
	2000's	377	396	451	459	477	635
	2010's	377	396	450	457	480	630
	2020's	379	397	451	460	482	602
Darlington	1990's	435	467	547	557	587	744
	2000's	445	485	546	557	578	727
	2010's	445	483	549	558	584	760
	2020's	433	468	549	571	664	723
Gentilly-2	1980's						
	1990's	522	495	734	754	780	829
	2000's	497	464	717	738	767	816
	2010's	449	427	674	694	726	781
Point Lepreau	1980's						
	1990's	522	495	723	741	767	805
	2000's	477	453	688	707	734	774
	2010's	497	473	721	743	770	812
	2020's	509	478	731	754	777	808

**Table 7: Aggregated Bundle Burnup Summary Statistics (Known + Estimated)**

Station	Burnup (MWh/kgU)					
	Mean	Percentile			Max	
		50th	90th	95th	99th	
Bruce A	193	200	267	276	294	706
Bruce B	184	187	218	226	248	506
Pickering A	209	206	273	286	304	521
Pickering B	192	192	227	237	256	595
Darlington	195	199	237	247	266	405
Gentilly-2	173	173	211	225	244	346
Point Lepreau	168	167	208	225	247	330
<b>Aggregated</b>	<b>191</b>	<b>192</b>	<b>243</b>	<b>261</b>	<b>287</b>	<b>706</b>

**Table 8: Aggregated Discharge Burnup Intervals (Known)**

Station	Number of bundles in burnup interval (upper bound inclusive)										
	0-220	220-300	300-350	350-400	400-450	450-500	500-550	550-600	600-650	650-700	700-750
Bruce A	395,611	260,290	3,545	341	162	108	49	30	12	6	2
Bruce B	773,879	69,126	665	103	27	11	4				
Pickering A	144,944	61,147	2,923	204	49	12	4				
Pickering B	416,430	71,456	369	113	32	13	6	4			
Darlington	502,381	158,346	183	18	1						
Gentilly-2	121,268	8,641	19								
Point Lepreau	111,183	6,773	24								
<b>Aggregated</b>	<b>2,465,696</b>	<b>635,779</b>	<b>7,728</b>	<b>779</b>	<b>271</b>	<b>144</b>	<b>63</b>	<b>34</b>	<b>12</b>	<b>6</b>	<b>2</b>

**Table 9: Aggregated Maximum Linear Power Rating Summary Statistics (Known + Estimated)**

Station	Linear Power Rating (kW/m)					
	Mean	Percentile				Max
		50th	90th	95th	99th	
Bruce A	40.2	42.8	52.0	53.2	55.7	63.7
Bruce B	39.3	41.1	44.9	45.9	47.6	52.8
Pickering A	42.7	45.4	52.3	53.6	55.2	62.2
Pickering B	42.7	45.1	50.1	51.3	53.4	60.6
Darlington	41.6	44.1	48.1	48.9	50.1	52.6
Gentilly-2	39.6	41.2	49.5	51.1	53.3	56.2
Point Lepreau	39.0	40.4	48.8	50.2	52.3	54.9
<b>Aggregated</b>	<b>40.8</b>	<b>42.8</b>	<b>49.7</b>	<b>51.5</b>	<b>54.2</b>	<b>63.7</b>

**Table 10: Aggregated Maximum Bundle Power Summary Statistics (Known + Estimated)**

Station	Bundle Power (kW)					
	Mean	Percentile				Max
		50th	90th	95th	99th	
Bruce A	631	673	817	836	875	1000
Bruce B	619	648	707	722	748	828
Pickering A	520	553	637	652	673	757
Pickering B	520	549	611	624	651	738
Darlington	661	699	766	779	801	843
Gentilly-2	621	646	778	802	837	880
Point Lepreau	612	634	766	788	819	862
<b>Aggregated</b>	<b>603</b>	<b>625</b>	<b>756</b>	<b>788</b>	<b>837</b>	<b>1000</b>

**Table 11: Aggregated Average Bundle Power Summary Statistics (Known)**

Station	Bundle Power (kW)					
	Mean	Percentile				Max
		50th	90th	95th	99th	
Bruce A	394	423	514	562	638	841
Bruce B	433	462	529	543	583	722
Pickering A	361	380	455	488	529	613
Pickering B	378	398	455	465	497	635
Darlington	441	478	548	558	595	760
Gentilly-2	495	466	717	739	771	829
Point Lepreau	496	471	714	735	768	812
<b>Aggregated</b>	<b>417</b>	<b>429</b>	<b>537</b>	<b>563</b>	<b>701</b>	<b>841</b>

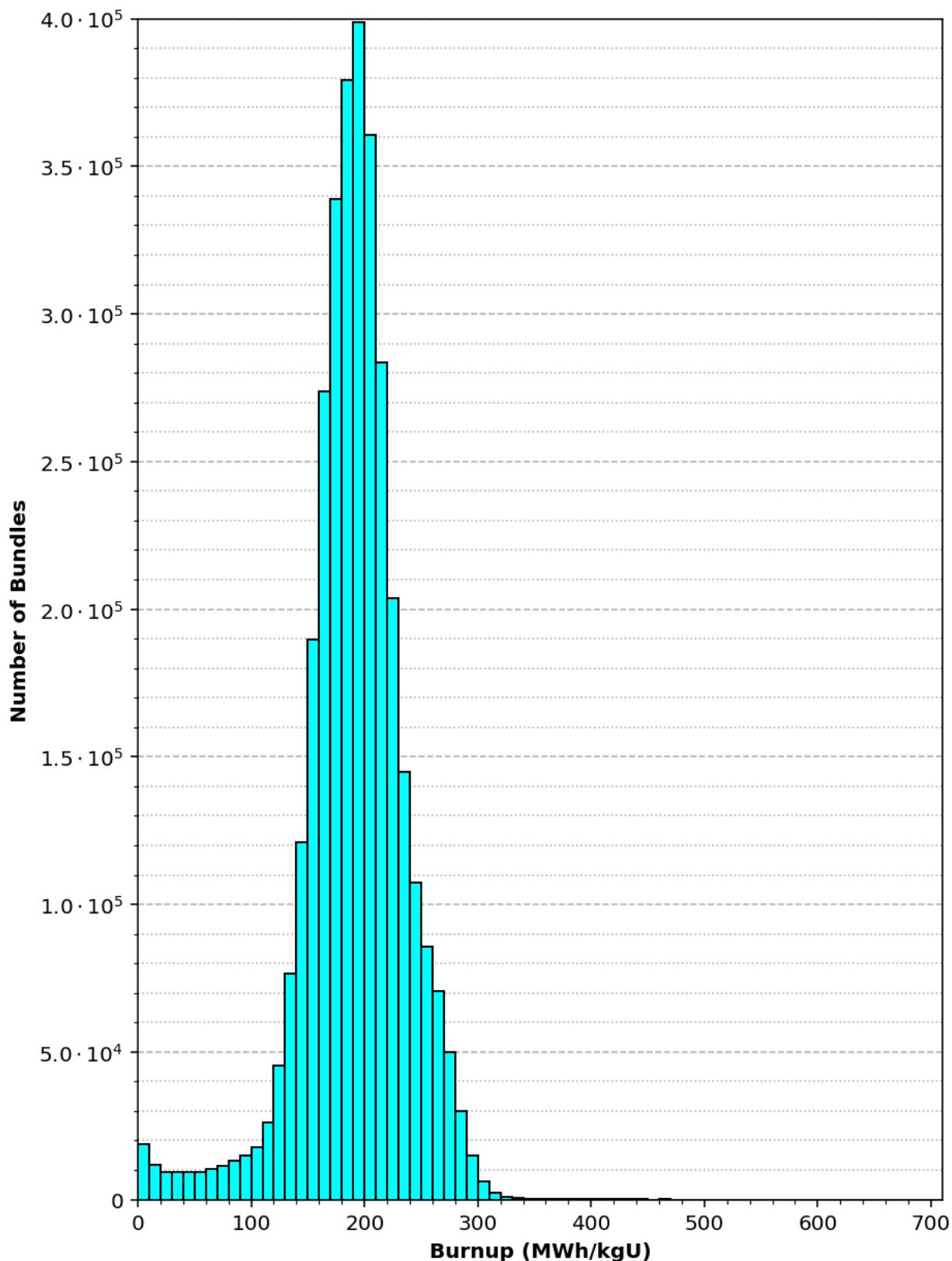


Figure 1: All Stations Bundle Discharge Burnups

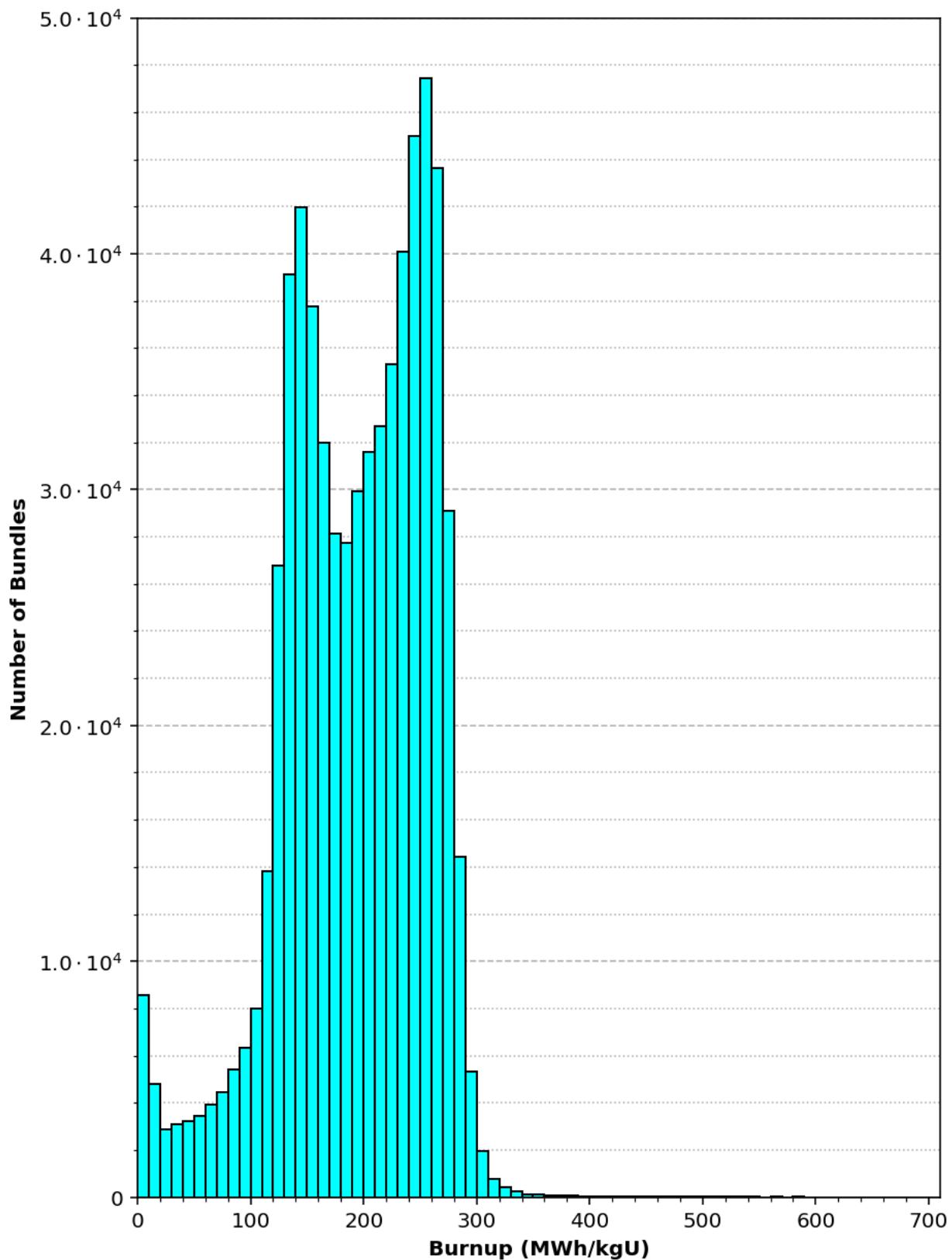


Figure 2: Bruce A Bundle Discharge Burnups

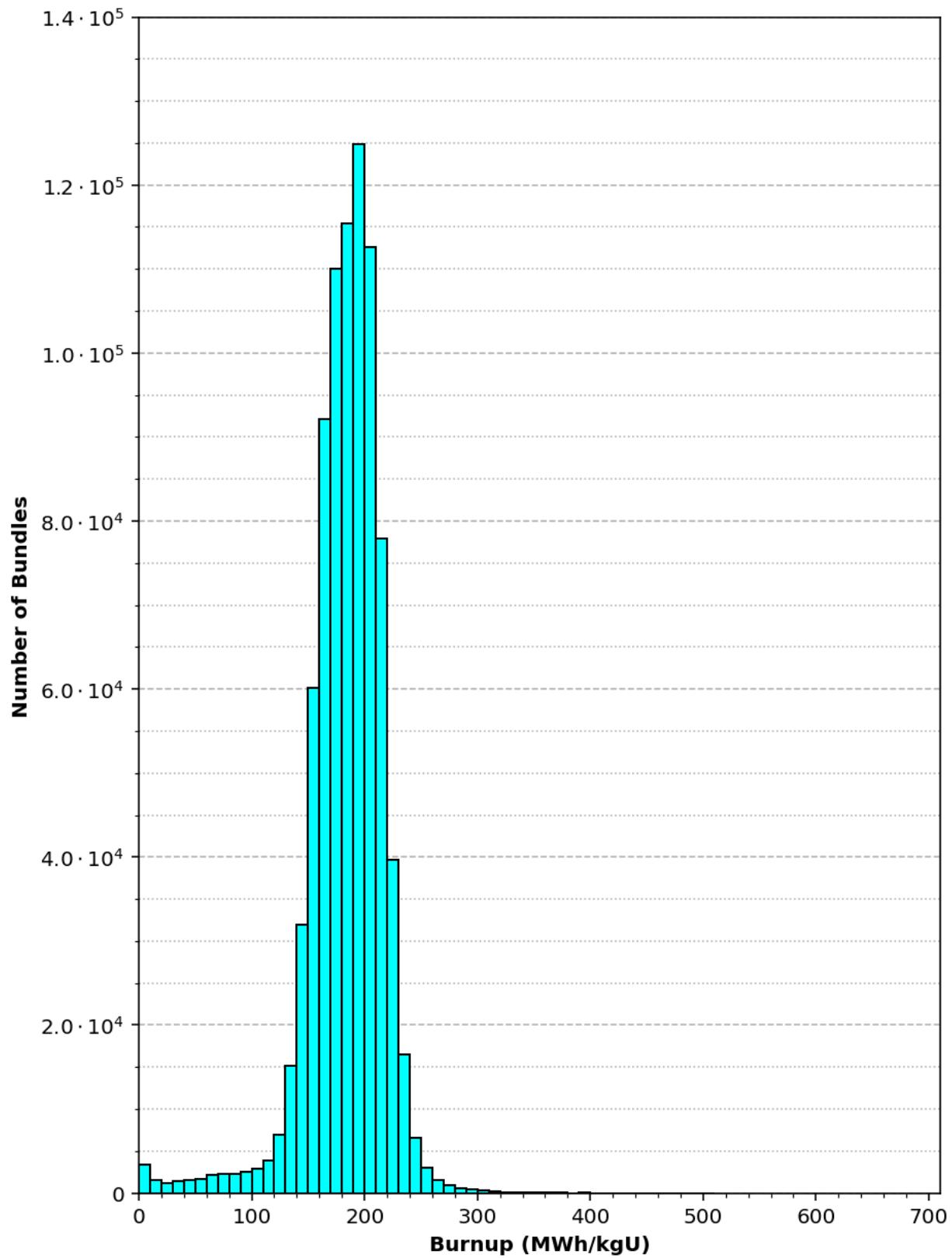


Figure 3: Bruce B Bundle Discharge Burnups

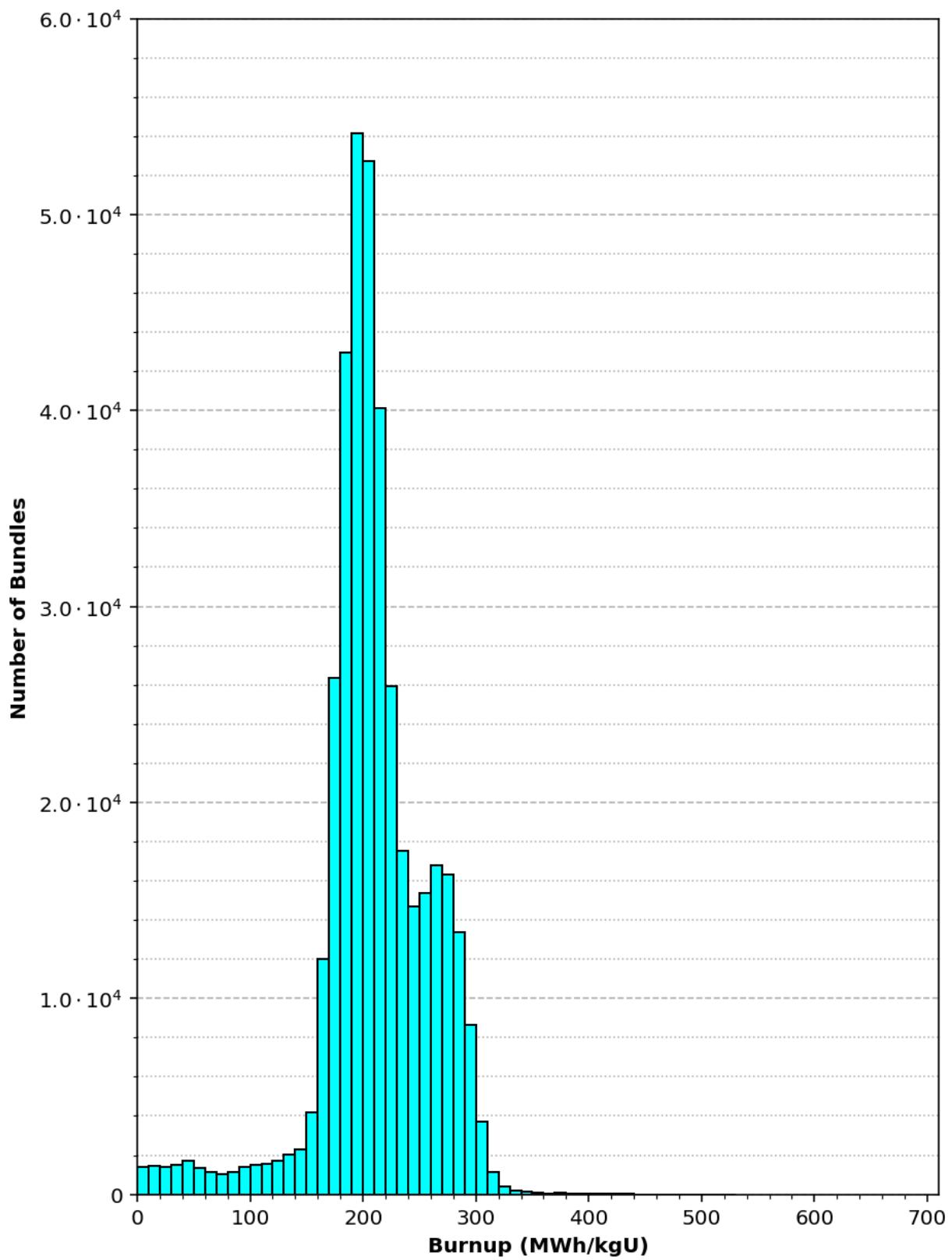


Figure 4: Pickering A Bundle Discharge Burnups

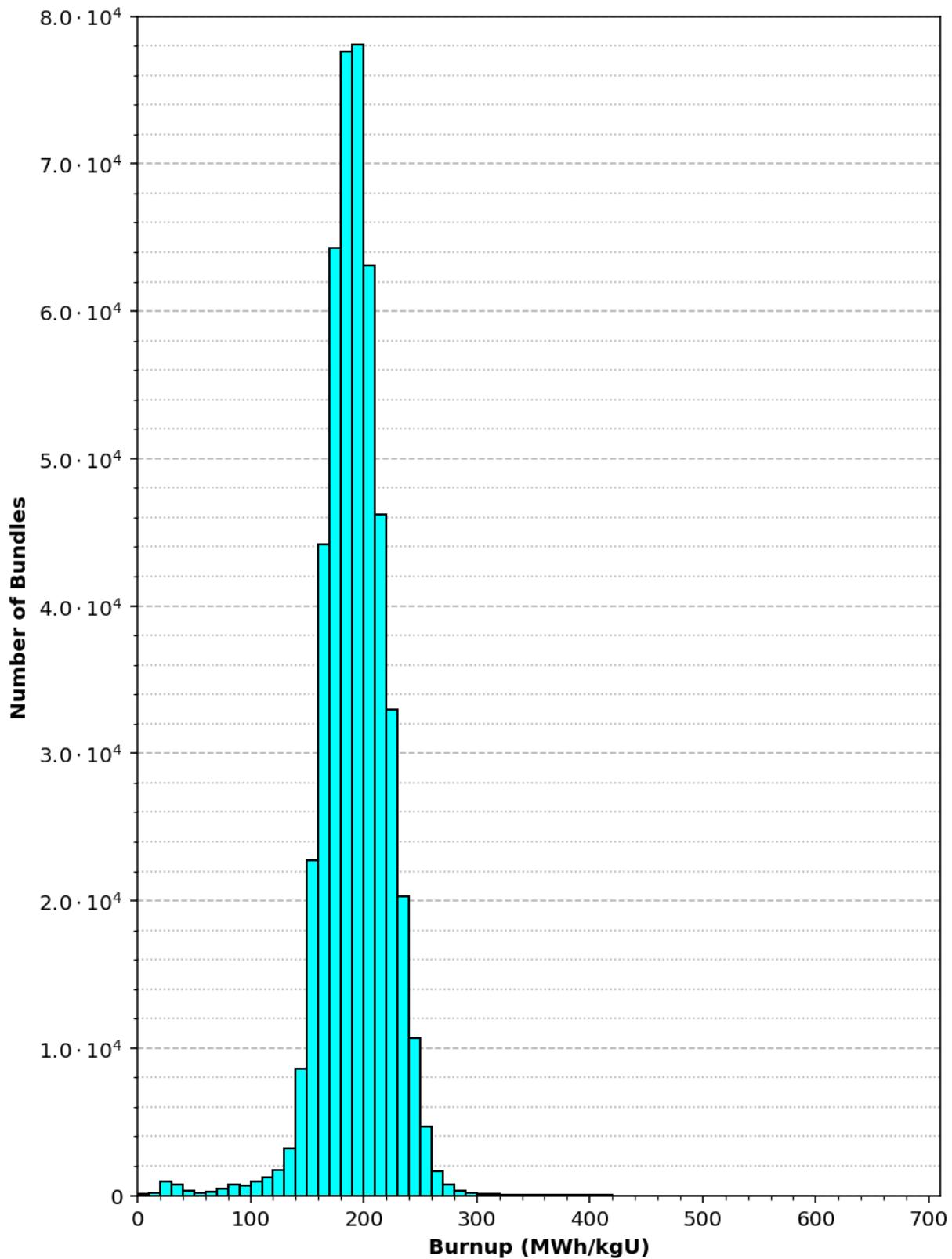


Figure 5: Pickering B Bundle Discharge Burnups

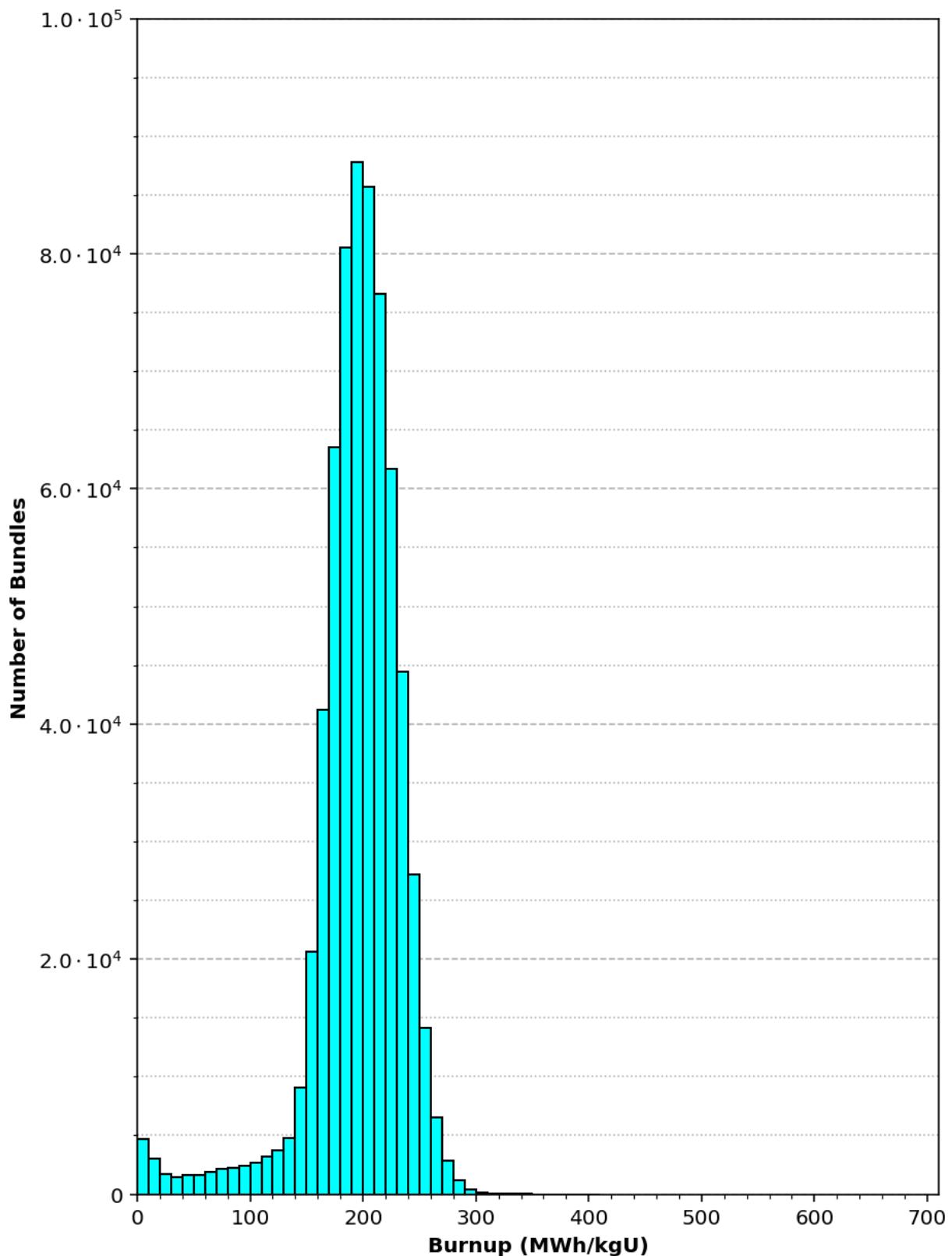


Figure 6: Darlington Bundle Discharge Burnups

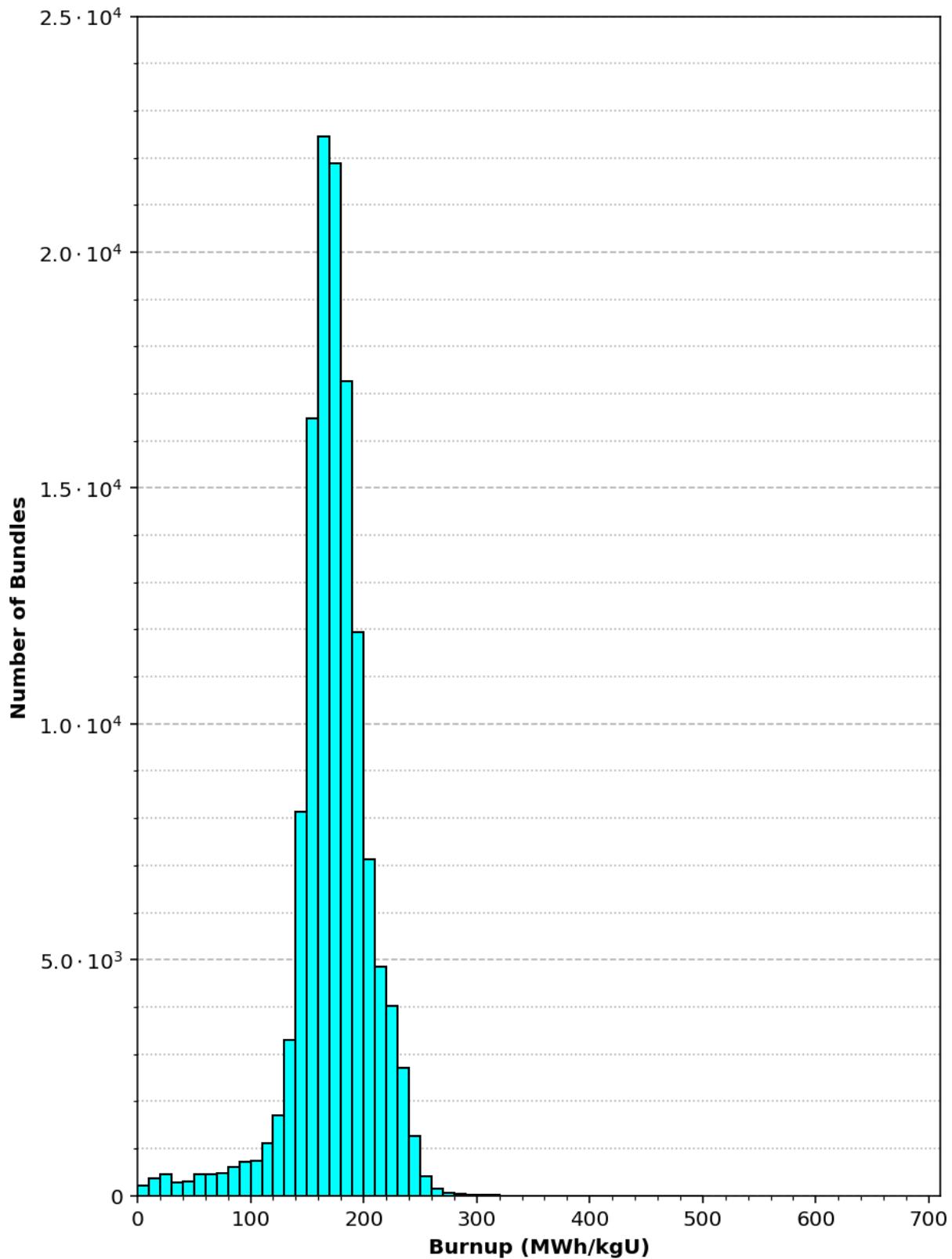


Figure 7: Gentilly-2 Bundle Discharge Burnups

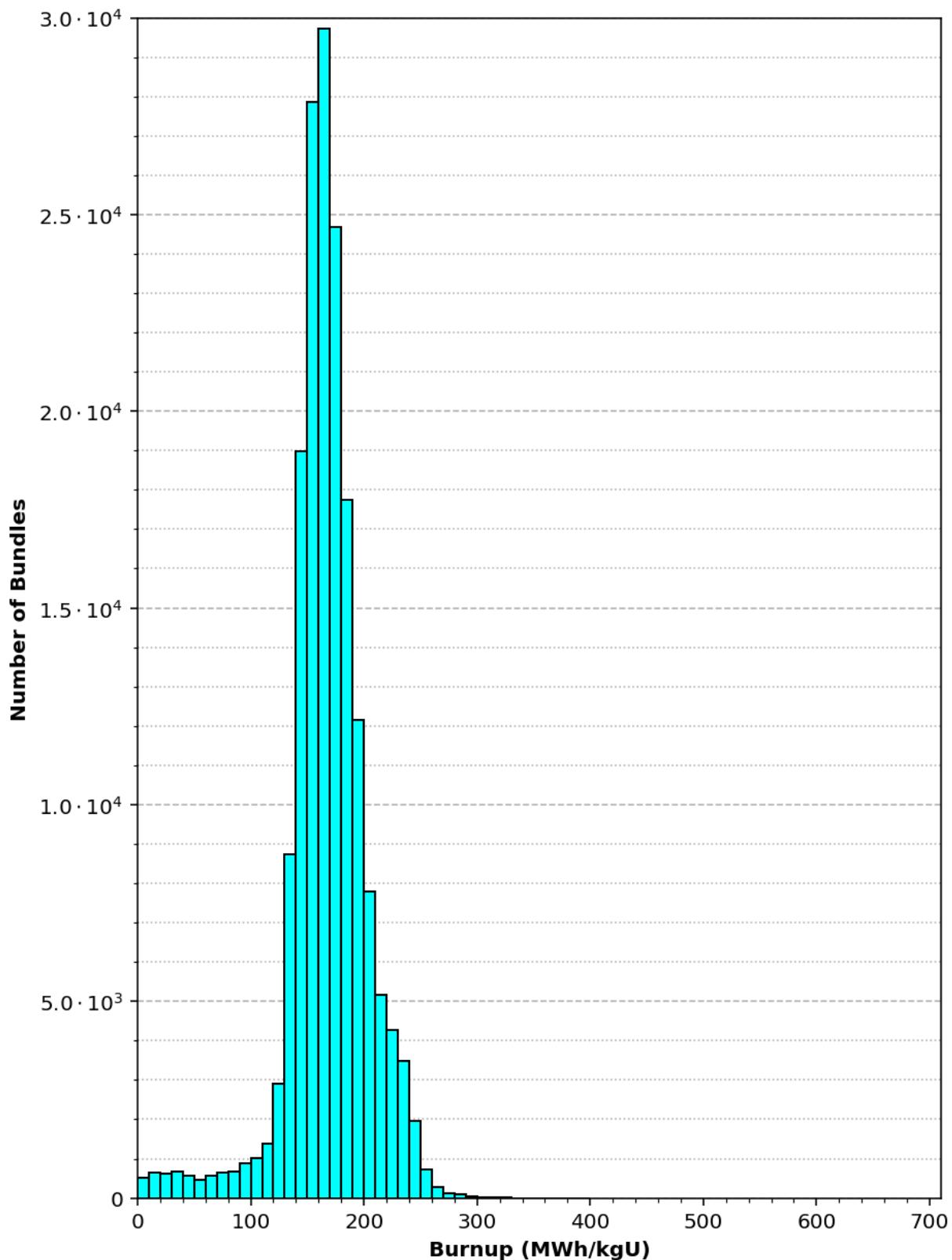
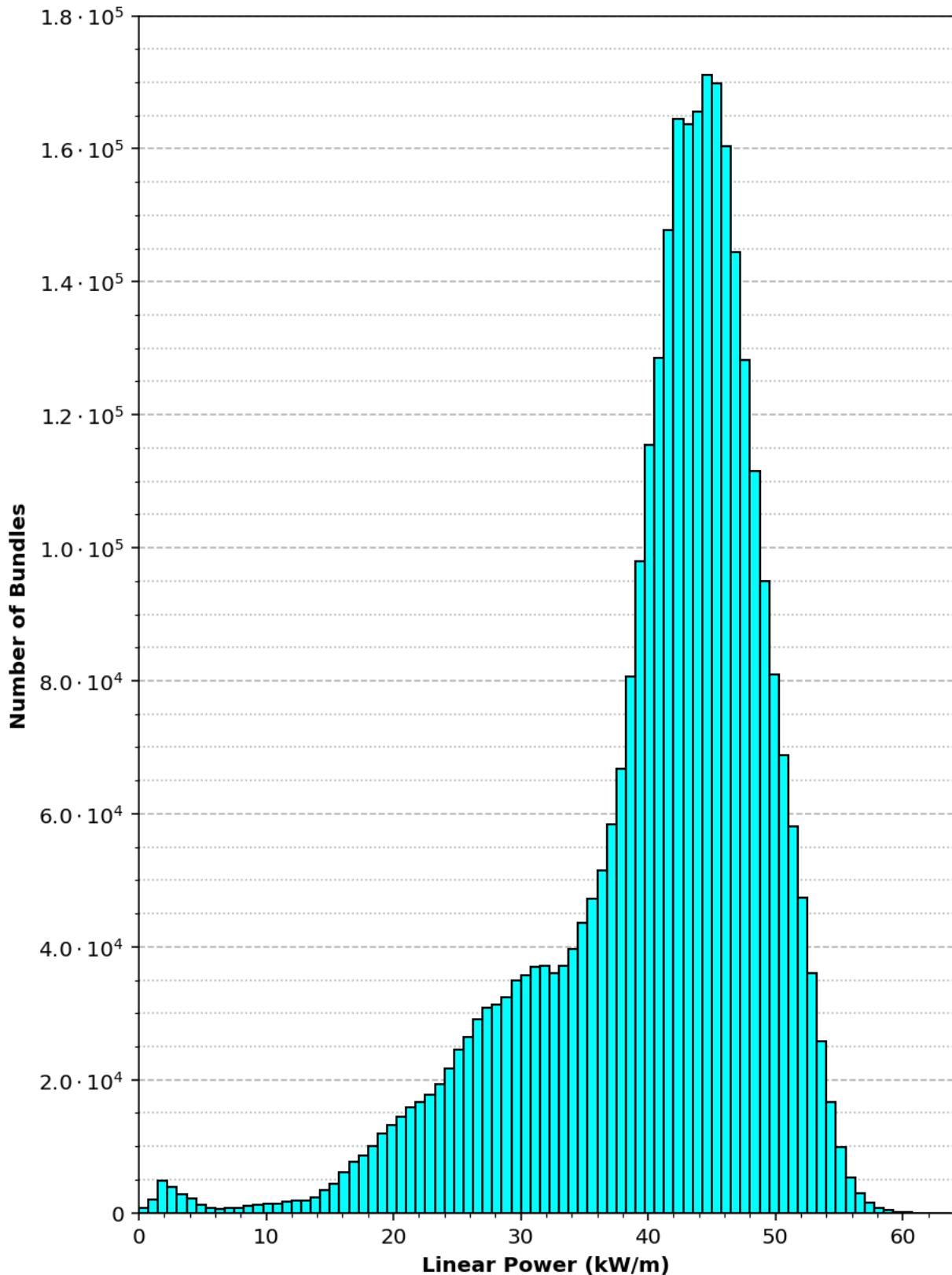


Figure 8: Point Lepreau Bundle Discharge Burnups



**Figure 9: All Stations Maximum Linear Power Ratings**

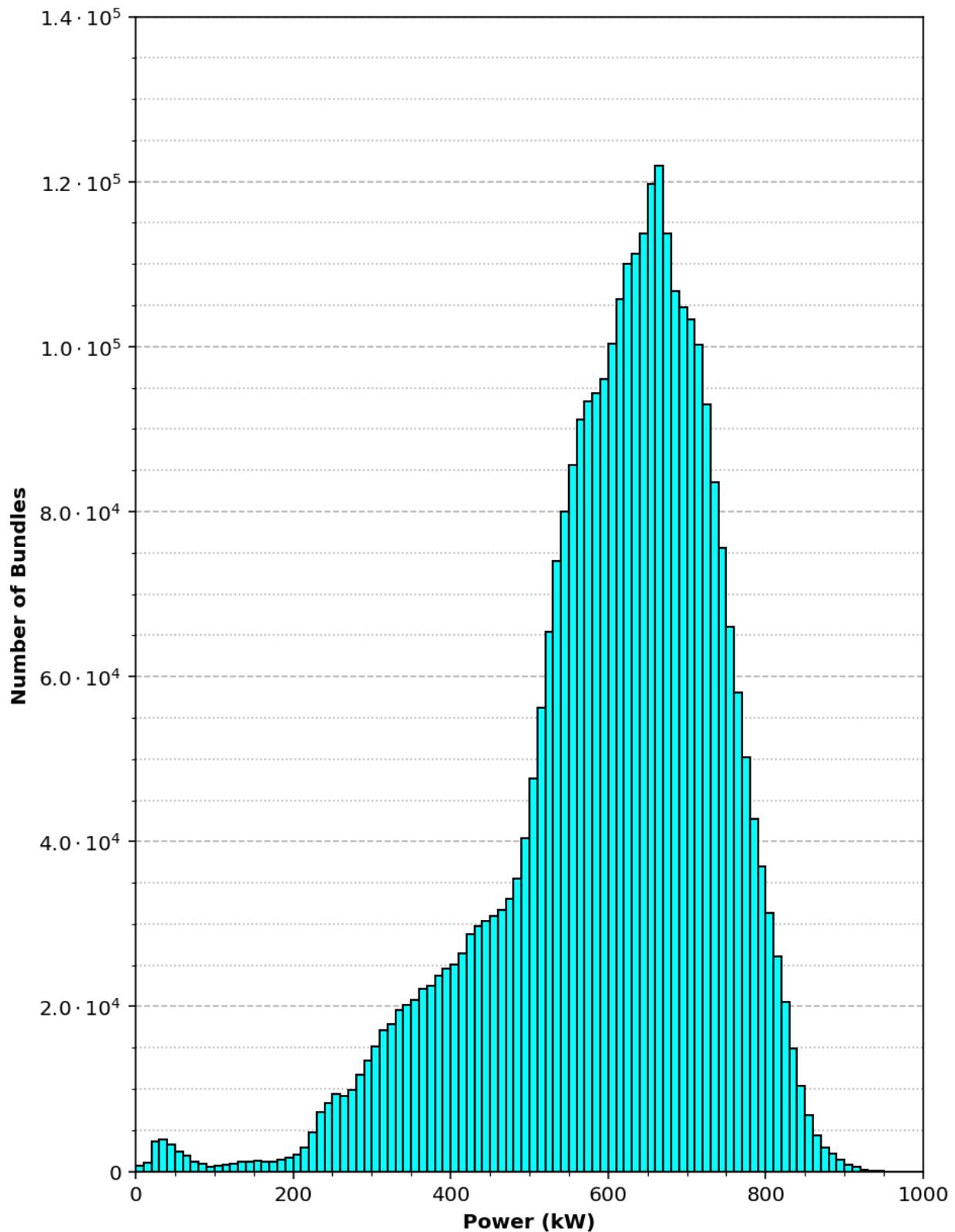


Figure 10: All Stations Maximum Bundle Power

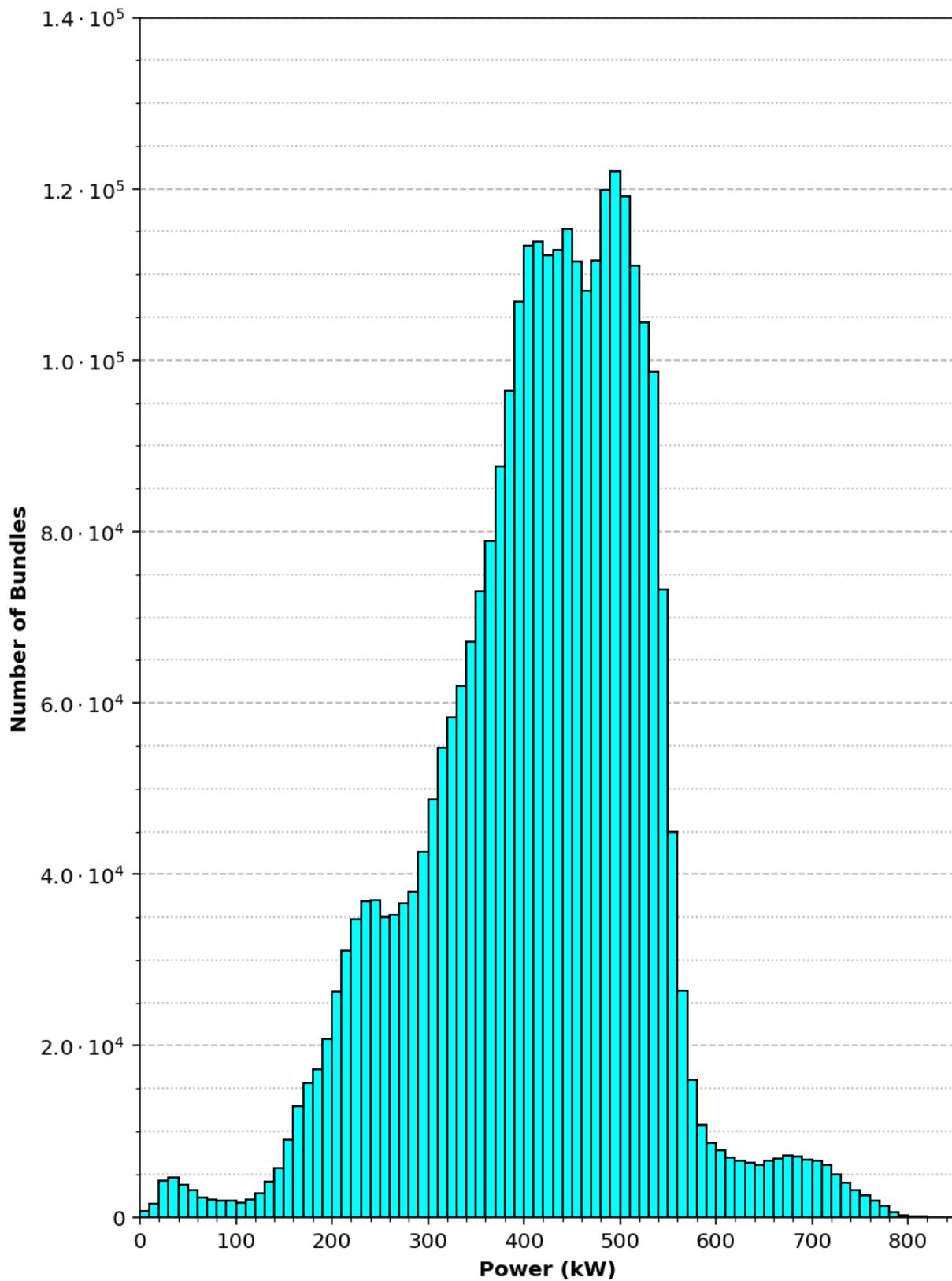
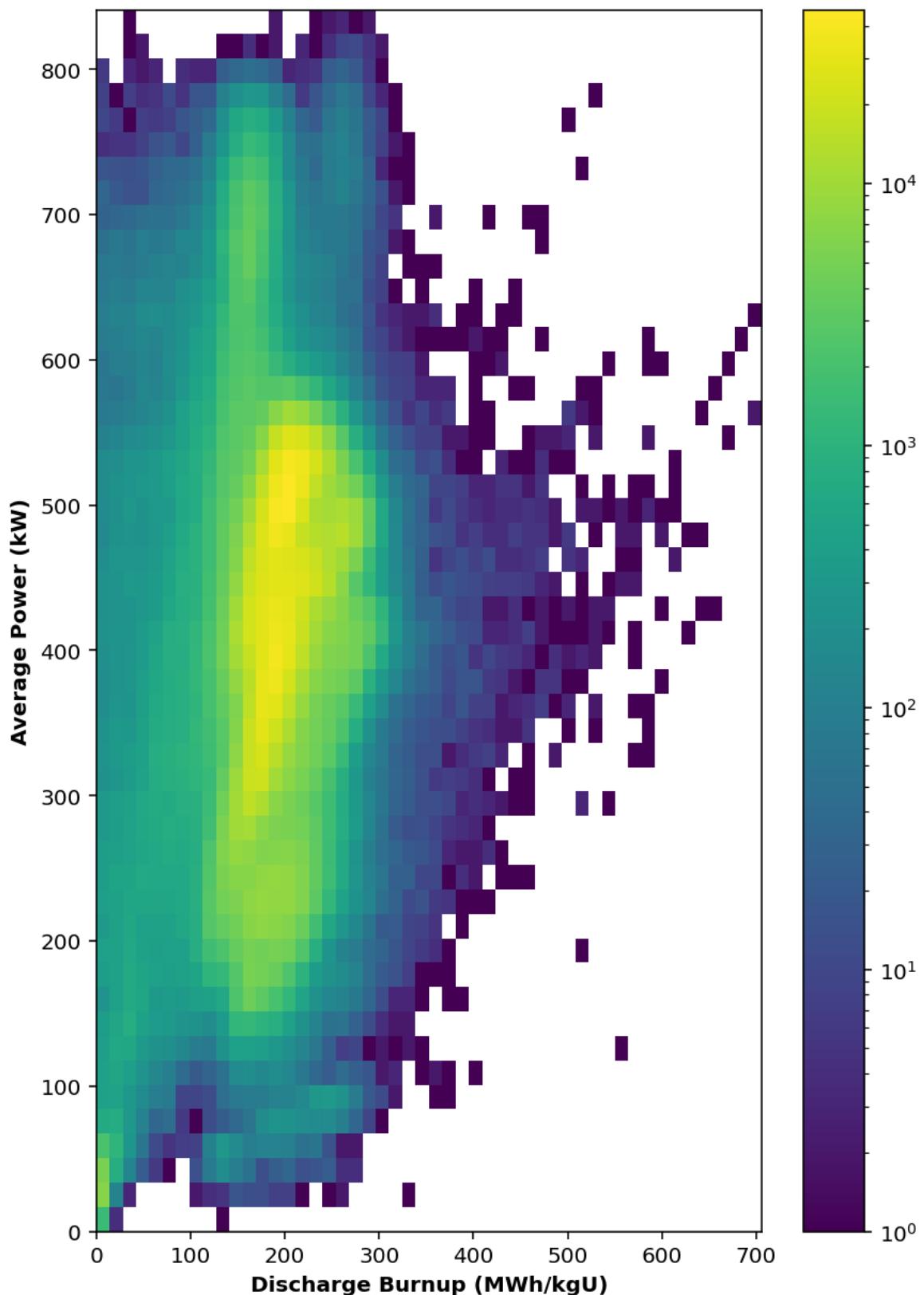


Figure 11: All Stations Average Bundle Power



**Figure 12: All Stations Discharge Burnup and Average Bundle Power Heatmap**

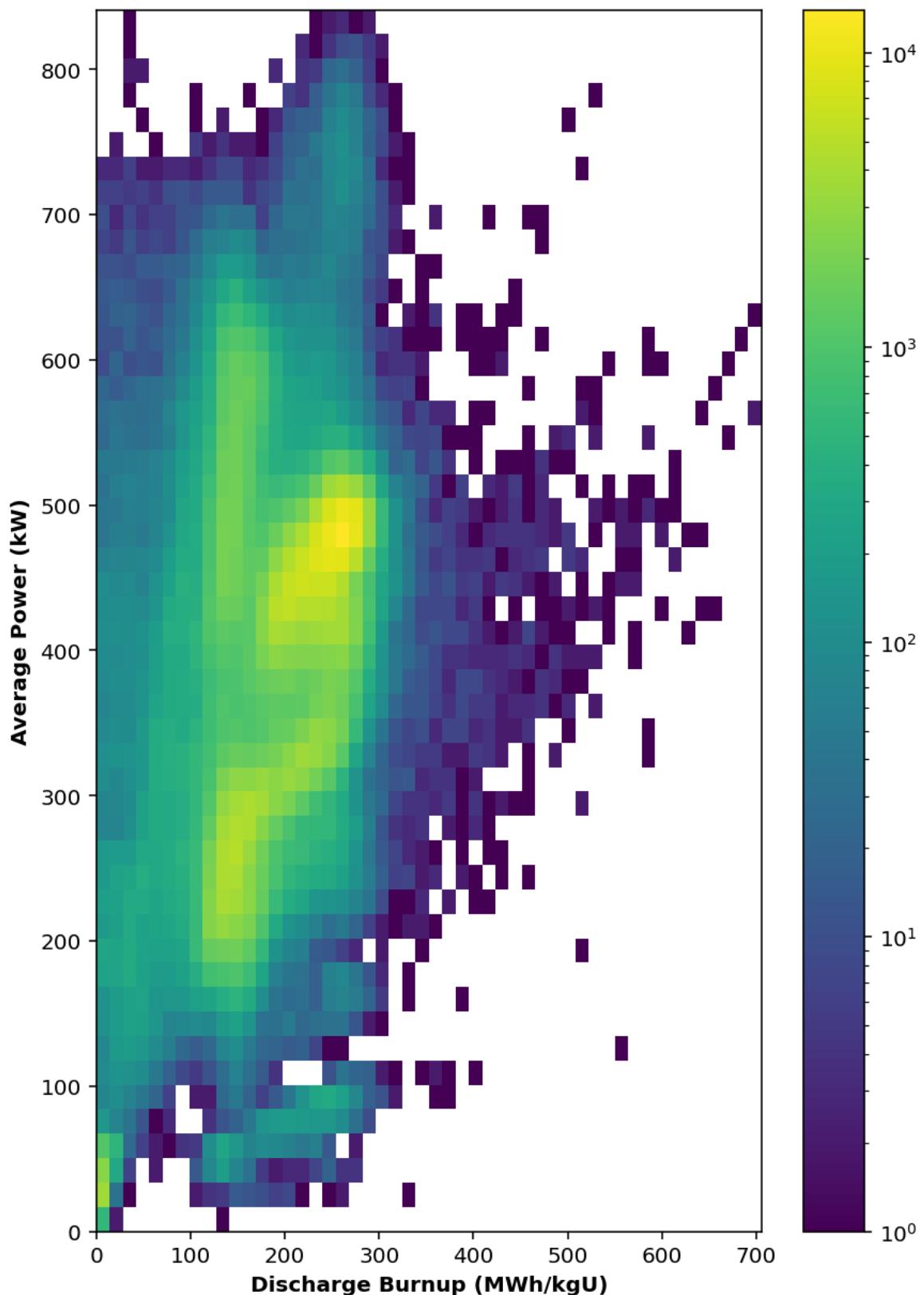
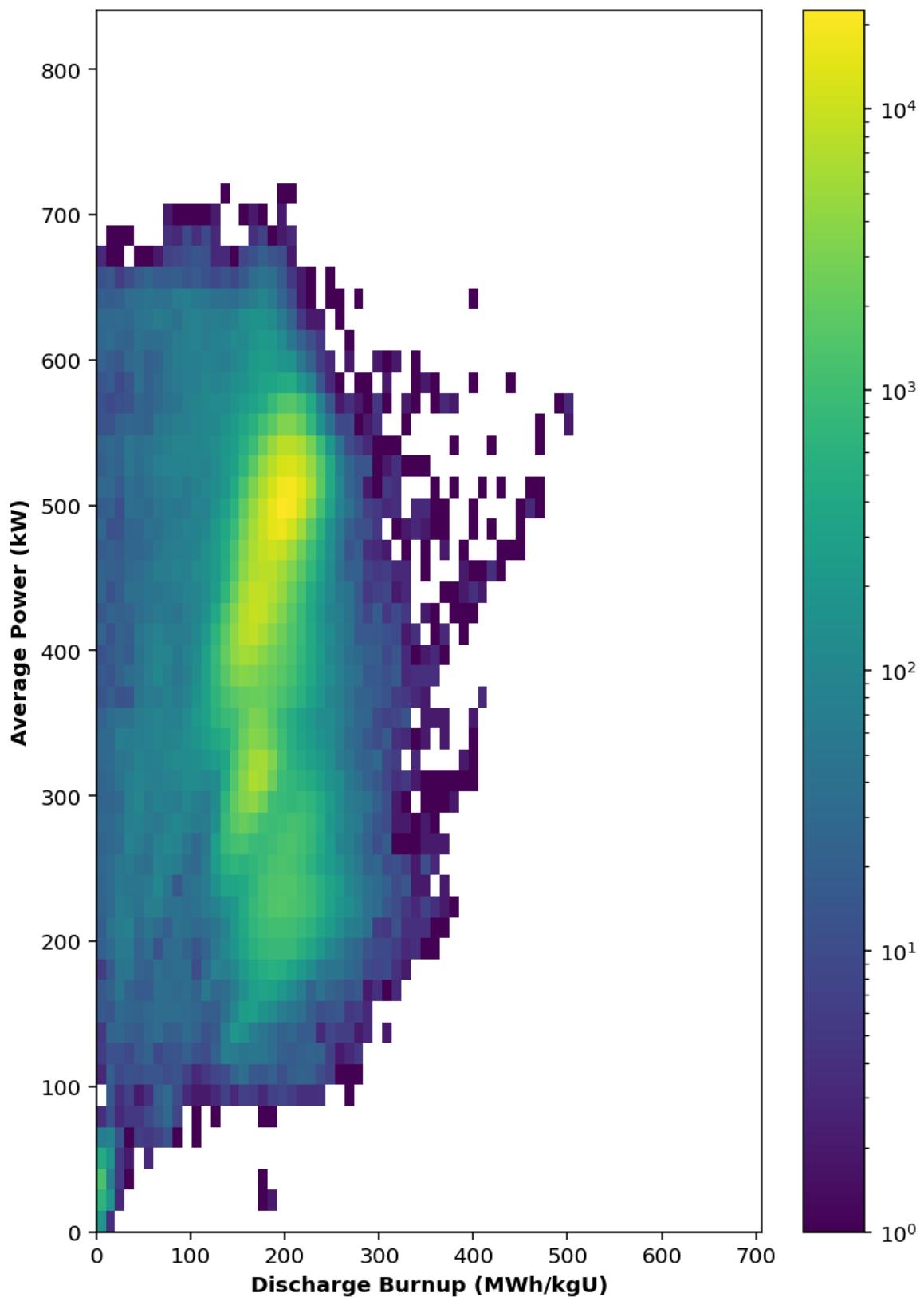
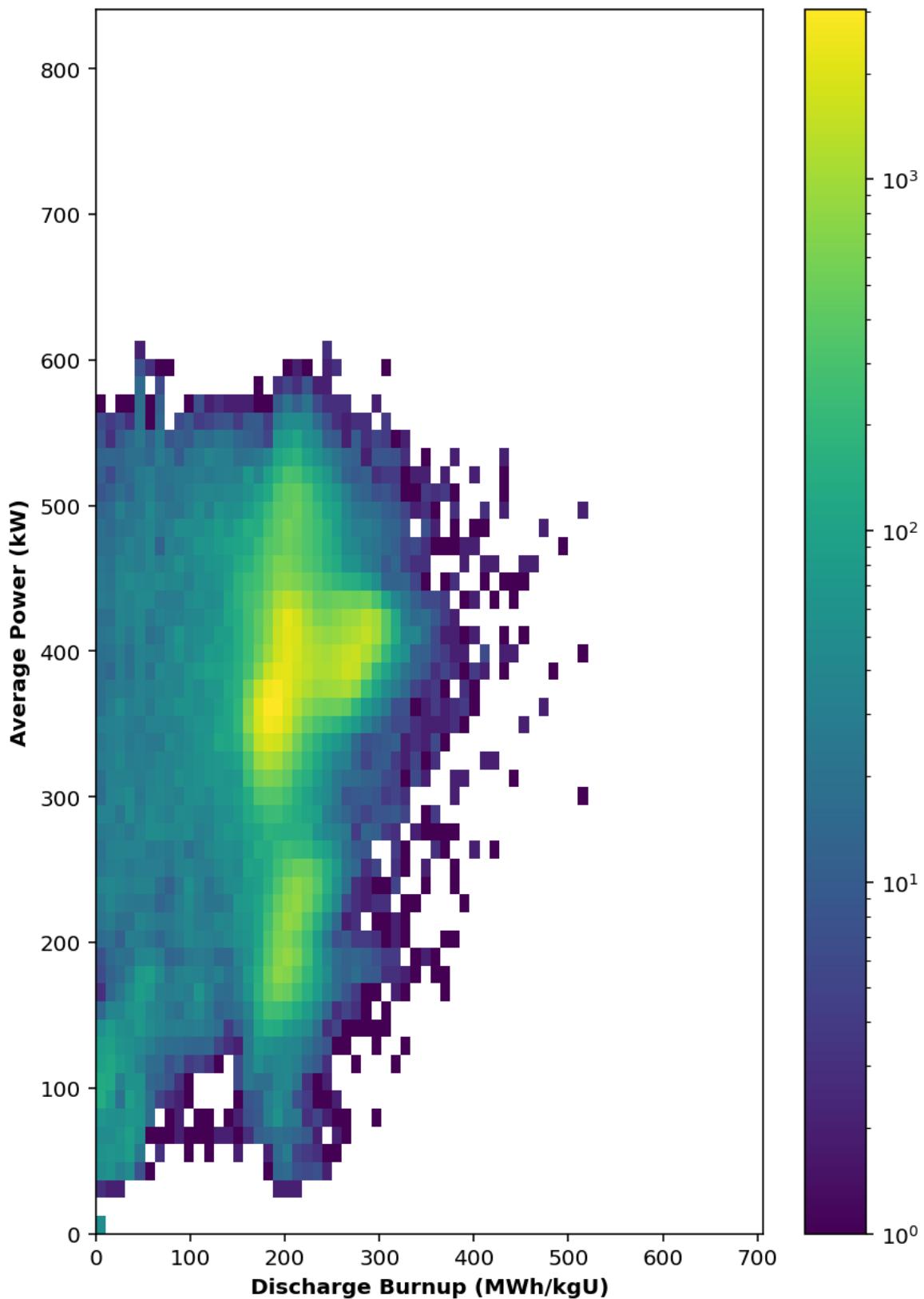


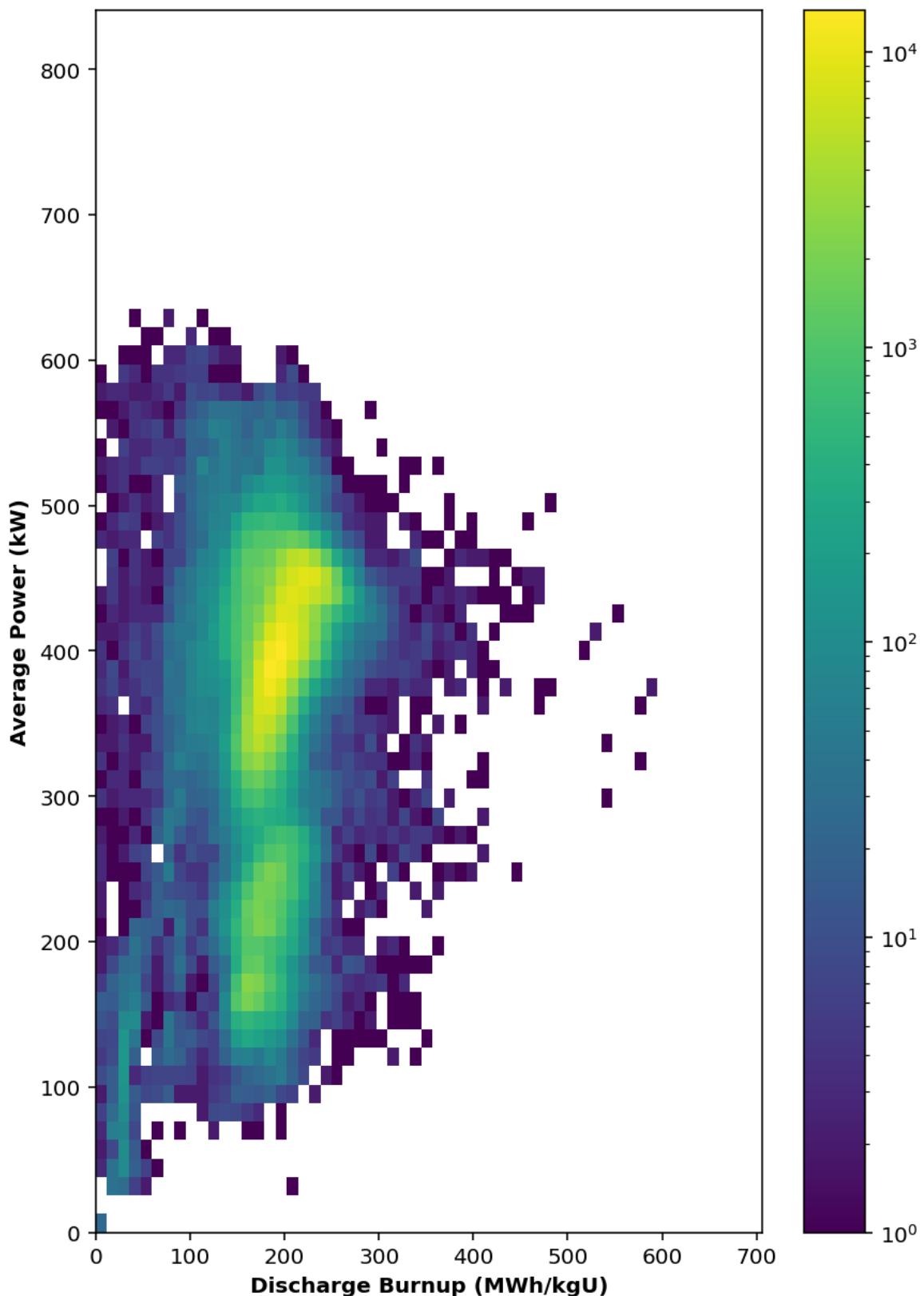
Figure 13: Bruce A Discharge Burnup and Average Bundle Power Heatmap



**Figure 14: Bruce B Discharge Burnup and Average Bundle Power Heatmap**



**Figure 15: Pickering A Discharge Burnup and Average Bundle Power Heatmap**



**Figure 16: Pickering B Discharge Burnup and Average Bundle Power Heatmap**

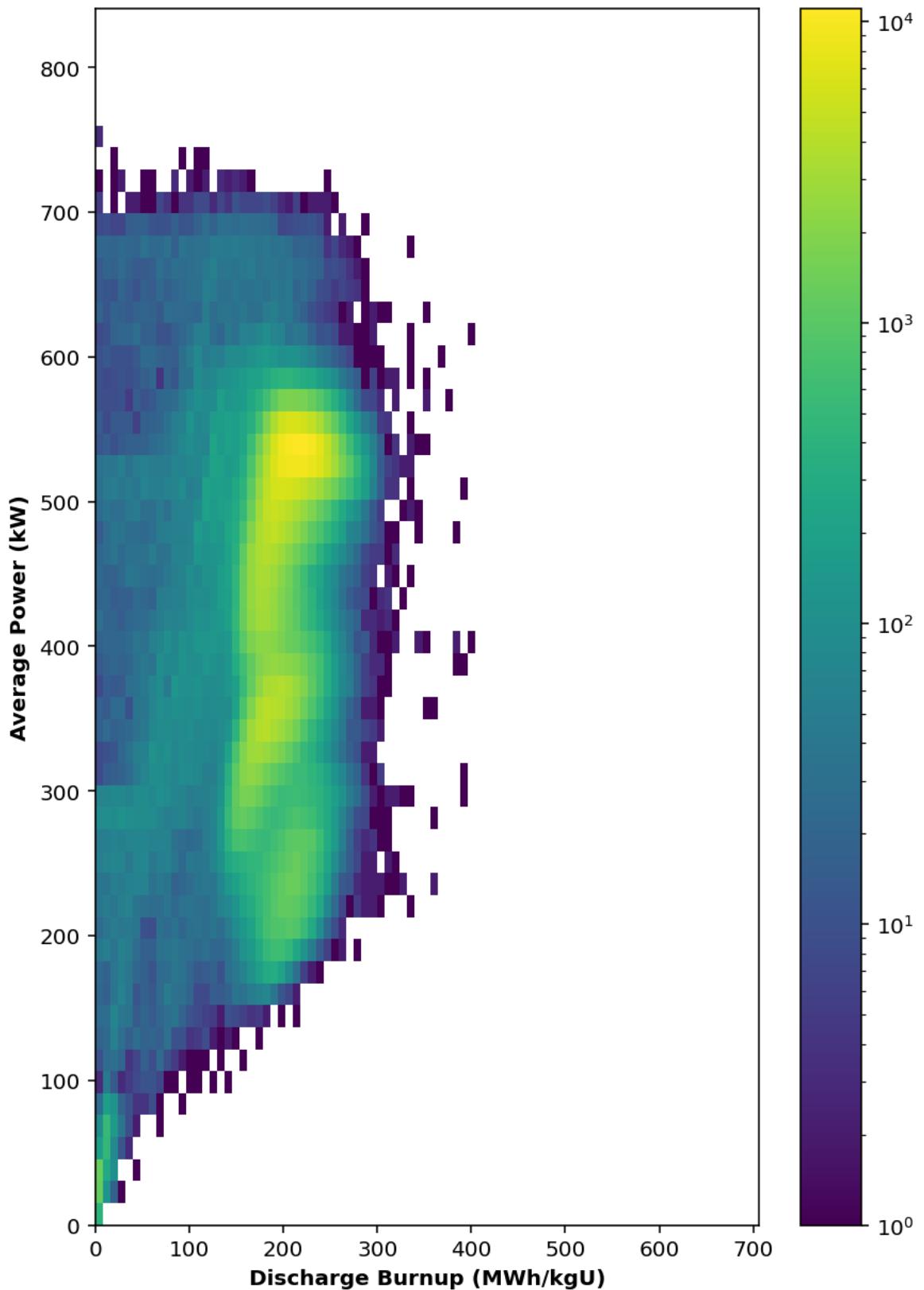


Figure 17: Darlington Discharge Burnup and Average Bundle Power Heatmap

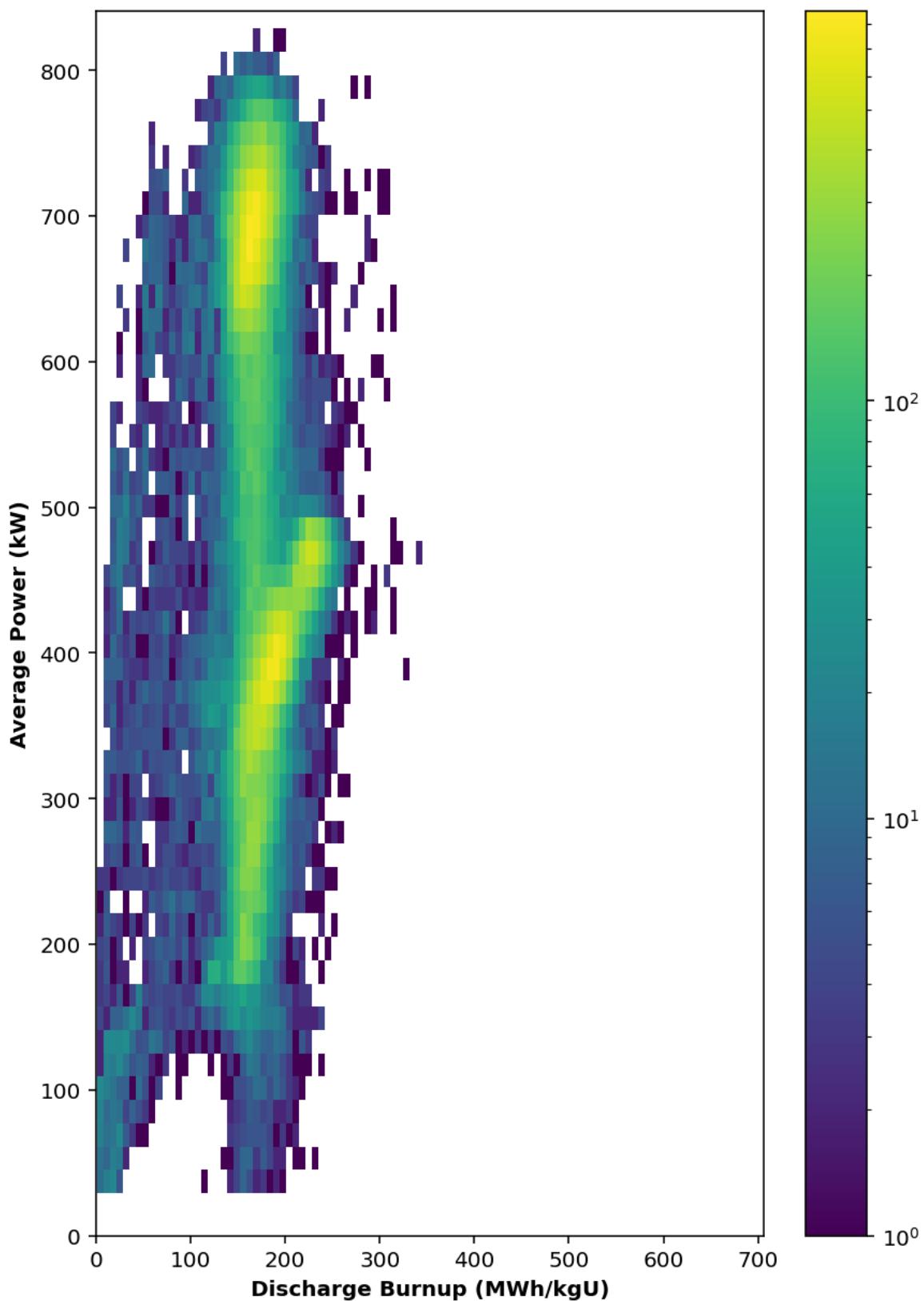
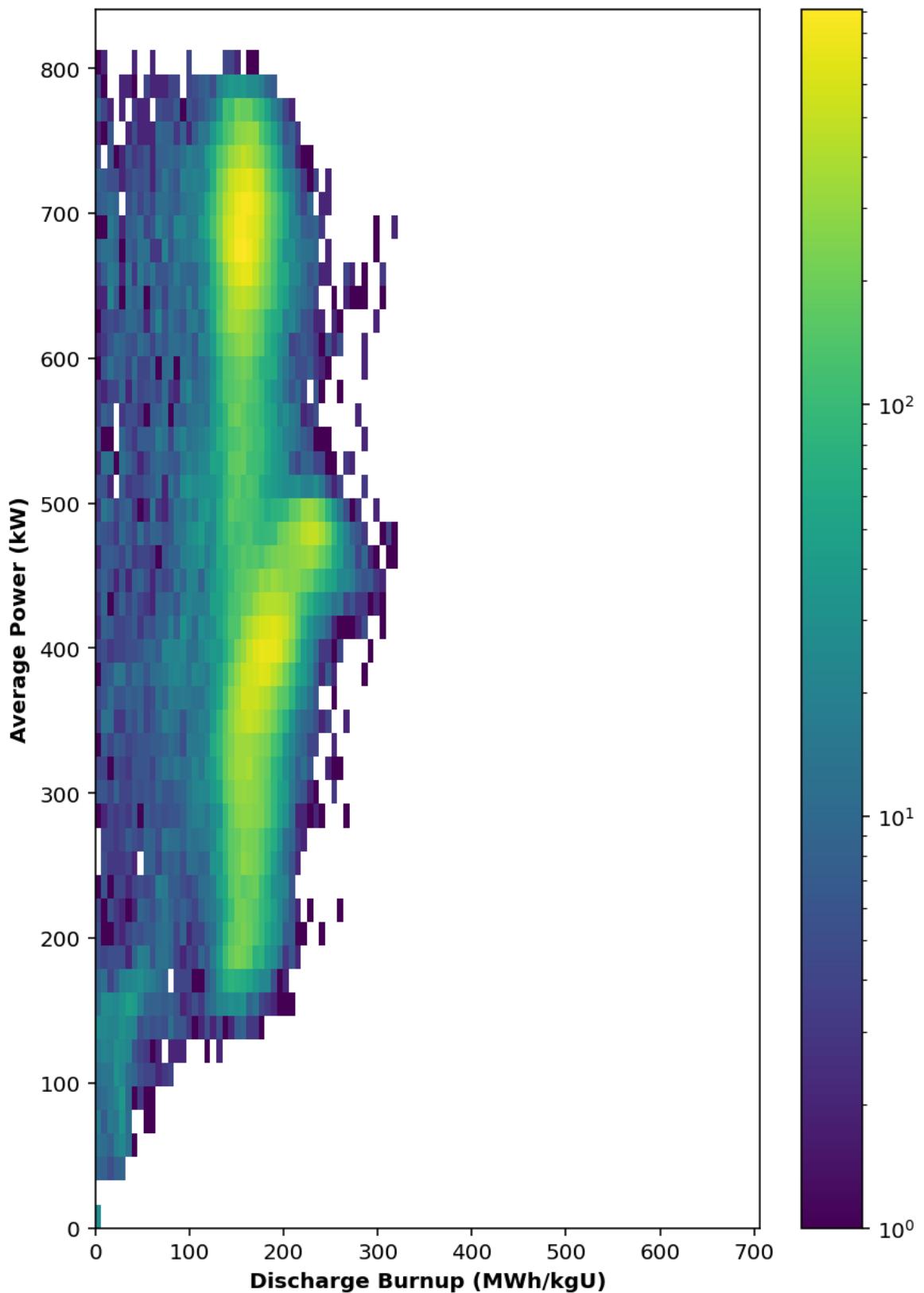


Figure 18: Gentilly-2 Discharge Burnup and Average Bundle Power Heatmap



**Figure 19: Point Lepreau Discharge Burnup and Average Bundle Power Heatmap**

## 5. CONCLUSIONS

Burnups and linear power ratings for fuel bundles that had been discharged from Ontario Power Generation, Bruce Power, Hydro-Quebec, and New Brunswick Power reactors were extracted from all available digital archives. Aggregated data for all stations were statistically analyzed and plotted as frequency histograms.

The total number of discharged fuel bundles that were used in this statistical analysis is approximately 3.3 million bundles consisting of both the known and estimated bundle discharges. Each utility's contribution to this total was as follows: 44.9% from Bruce Power, 46.0% from Ontario Power Generation, 3.9% from Hydro-Quebec, and 5.2% from New Brunswick Power.

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## REFERENCES

Lampman, T. 2021. Update to Fuel Burnups and Power Ratings. Nuclear Waste Management Organization Report NWMO-TR-2019-04. Toronto, Ontario.

Wilk, L. 2013. Update to Fuel Burnups and Power Ratings. Nuclear Waste Management Organization Report NWMO-TR-2013-02. Toronto, Ontario.

Wilk, L., G. Cantello. 2006. Used Fuel Burnups and Power Ratings for OPG Owned Used Fuel. Prepared by Nuclear Safety Solutions Limited for Ontario Power Generation. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01300-10121-R00. Toronto, Ontario.

Wilk, L. 2005. SORO Theory Manual. Kinectrics Manual G0027/MA/002 R00. Toronto, Ontario.