Load Estimates and Cogeneration Economics for Kennedy-King College

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Executive Summary

Investment Summary

- Campus: 8 Buildings Totaling 477,000 SF
  - Electric Load: 1530 kW Maximum
  - Excluding Cooling & Central Plant Equipment
- System Proposed: On-Site Cogeneration
  - On-Site Generator
  - Rejected Heat Passing to Cooling and Heating System

Equipment Required

- Engine Generator: 1,110 kW
- Cooling
  - One Absorption Chiller: 200 tons
  - Remainder of Cooling Equipment – Electric
  - Standard Chilled Water Delivery 40-45F
- Heating
  - Engine Hot Water Recovery Heat Exchanger
  - Central Gas Fired Boilers
  - Water Delivery 180-200 F

Economic Overview

- Net Operating Cost Savings: ~$250,000/Yr.
  - Versus All Electric Chiller and Gas Heating Plant
  - 6L Electric Rate, $4.00/MMBtu Gas
- Added First Cost: ~$1,500,000
  - Above Cost of Conventional Central Cooling and Heating Plant
- Simple Payback: 6 Yrs.
- Internal Rate of Return at 16%

Preliminary First Cost Comparison

	Optimim Generator Size	Preliminary First Cost	Operating Savings	Payback Period
	kW	*$*	*$/Yr*	*Yr*
Simple Electric Chiller Plant	NA	$671,000	Baseline	
Engine-Generator Plant	1,450	$2,496,000	$215,000	8.49
Engine-Generator Plant Heating Only Cogen	1,300	$2,331,000	$225,000	7.38
Engine-Generator Plant with Heaing and Cooling Cogen	1,100	$2,189,600	$250,000	6.07

Electric Generating Plant with
Cooling and Heating Provides Best Payback

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Pro Forma Analysis

Economic Analysis

Interest or Bond Rate 6.0%

Tax Rate 0%

Project: Kennedy-King City College

Scenario: Cogeneration with Heating and Cooling

Values Shown are for Concept Level Evaluation Only - Not Sufficient for Investment Purposes

IRR= 16%

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Added Installed Cost of Plant ($1000)	$1,500																				
Price and Sales Data																					
Gross Revenues																					
Operating Cost Savings Vs Std Electric Plant	1000$	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290
Total		$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290	$290
Operating Costs																					
Maintenance Cost of Generator System	1000$	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40
Added Maint. Cost of Chillers Vs. Std. Electric	1000$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	1000$	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40
Total Net Revenue	1000$	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250
Internal Rate of Return Calculation																					
In/Outflows ($1,000)	-$1,500	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250
IRR =	**15.78%**																				
Non-Profit or Institutional Owner																					
Cost of Financing - Uniform Payments	1000$	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131	-$131
Net Income After Capital Payments	1000$	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119
Principle Repayment Component	1000$	-$41	-$43	-$46	-$49	-$51	-$55	-$58	-$61	-$65	-$69	-$73	-$77	-$82	-$87	-$92	-$98	-$104	-$110	-$116	-$123
Principal Balance	1000$	$1,459	$1,416	$1,370	$1,322	$1,270	$1,216	$1,158	$1,096	$1,031	$963	$890	$812	$730	$643	$551	$453	$350	$240	$123	$0

Details of the Engineering Analysis

Engineering Analysis Overview

- Information Available
  - Building Sizes
  - Building Functions
  - Initial Connected Power Load Estimates
  - Design Maximum Occupancies
- Assumptions Based on Existing City College Audits
  - Schedules
  - Reduction of Design Maximum Values to Typical Daily Values
- Pre-Concept Cogeneration Analysis Only

Loads Development

- Assumptions Vary Per Specific Building
  - File Assembled on Assumed Loads and Schedules
- Loads Outputs
  - Monthlies (Summarized in Attached Charts)
    - Include Cooling System per Building
- Hourly Loads
  - All Cooling Equipment including Tower and Tower Pumps will be Stripped Out
  - Will Fully Account for Non-Coincidence of Loads from Different Buildings
  - Essential for Reasonable Predictions on Cogeneration

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Sample of Check Values from City Audits

Existing City Colleges Buildings		Building Size	Est. Typical Occupancy	Typical SF/person	Max (Summer) Electric Demand	Max Summer Demand (inc HVAC)	Typical Winter Demand	Winter Max Power Use (Not inc AC)	Monthly Electric Usage	Annual Electric Usage Estimate	Monthly Electric Usage	Notes
		(sf)		(sf/person)	(kW)	(W/sf)	(kW)	(kW/sf)	(kWh/Mo)	(kWh/Yr)	(kWh/sf)	
Daley		462880	800	579	1700	3.67	NA - Electric Heat		More Detail for Main Building			Electric Heat Demand Not Included
Daley Main Building		374400	600	624	1316	3.51	NA - Electric Heat		12 Months Avail	3870606	10.34	Newer Building, Net of Electric Heat
Truman		569000	500	1138	2400	4.22	1600.00	2.81	617601.67	7411220	13.02	Low Typical Occupancy Due to Large Theater/Gym/Pool Building
Dawson		147000	300	490	1200	8.16	NA - Electric Heat		274185.67	3290228	22.38	
Malcolm X		540000	800	675	2360	4.37	1600.00	2.96	12 Months Avail	10469513	19.39	No Electric Heat
Olive Harvey		Not Applicable - Electrically Heated Building									23.67	

Simulation Result Values

Simulation Outputs for Comparison												
New Kennedy King Buildings		Building Size	Est. Typical Occupancy	Typical SF/person	Max (Summer) Electric Demand	Max Summer Demand (inc HVAC)	Min Winter Demand	Winter Max Power Use (Not inc AC)	Monthly Electric Usage	Annual Electric Usage Estimate	Monthly Electric Usage
Kennedy-King Building 1 - Kitchen Only		20000		200	282	14.10	242	12.10		758019	37.90
Kennedy-King Building 1 - Classrooms Only Only		30037		200	132	4.39	94	3.13		402272	13.39
Kennedy-King Building 2		60135		75	435	7.23	312	5.19		1099657	18.29
Kennedy-King Building 3		5714		350	30	5.25	17	2.98		94114	16.47
Kennedy-King Building 4		36884		400	169	4.58	123	3.33		513610	13.93
Kennedy-King Building 5		63656		200	177	2.78	139	2.18		810366	12.73
Kennedy-King Building 6		36671		400	155	4.23	125	3.41		784454	21.39
Kennedy-King Building 7		171100		400	711	4.16	513	3.00		2139353	12.50
Kennedy-King Building 8		42563		400	184	4.32	132	3.10		552684	12.99

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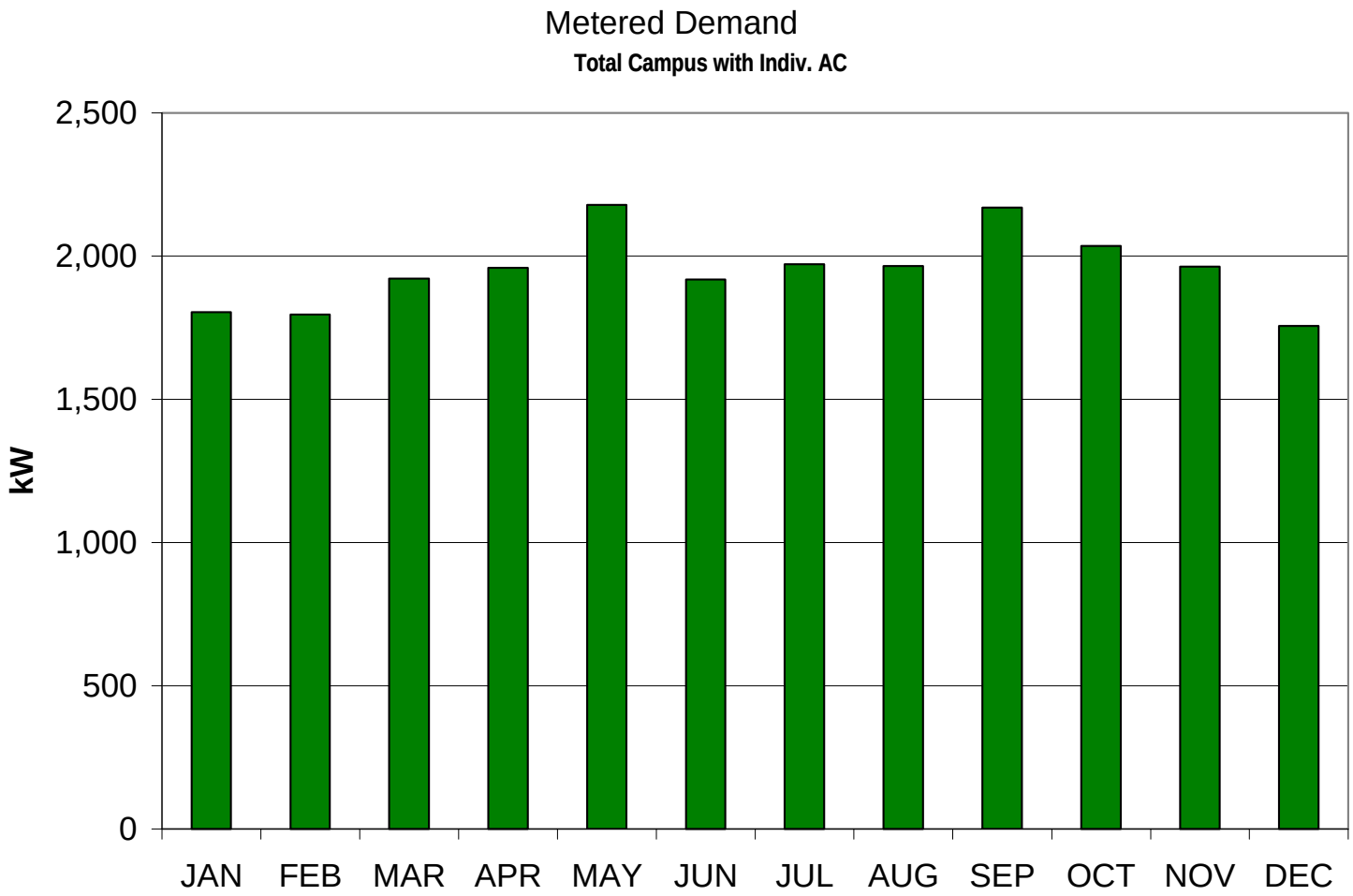
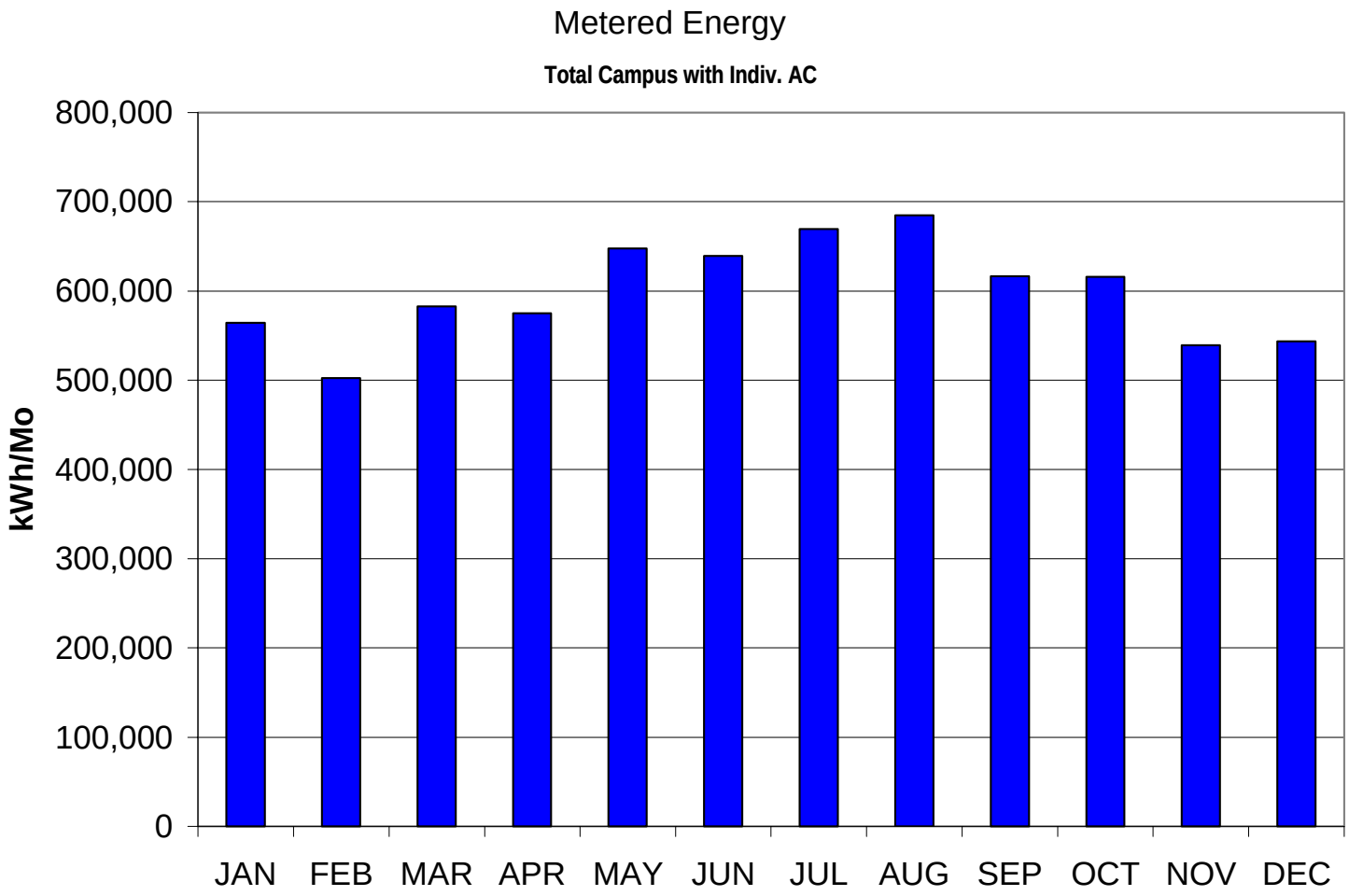
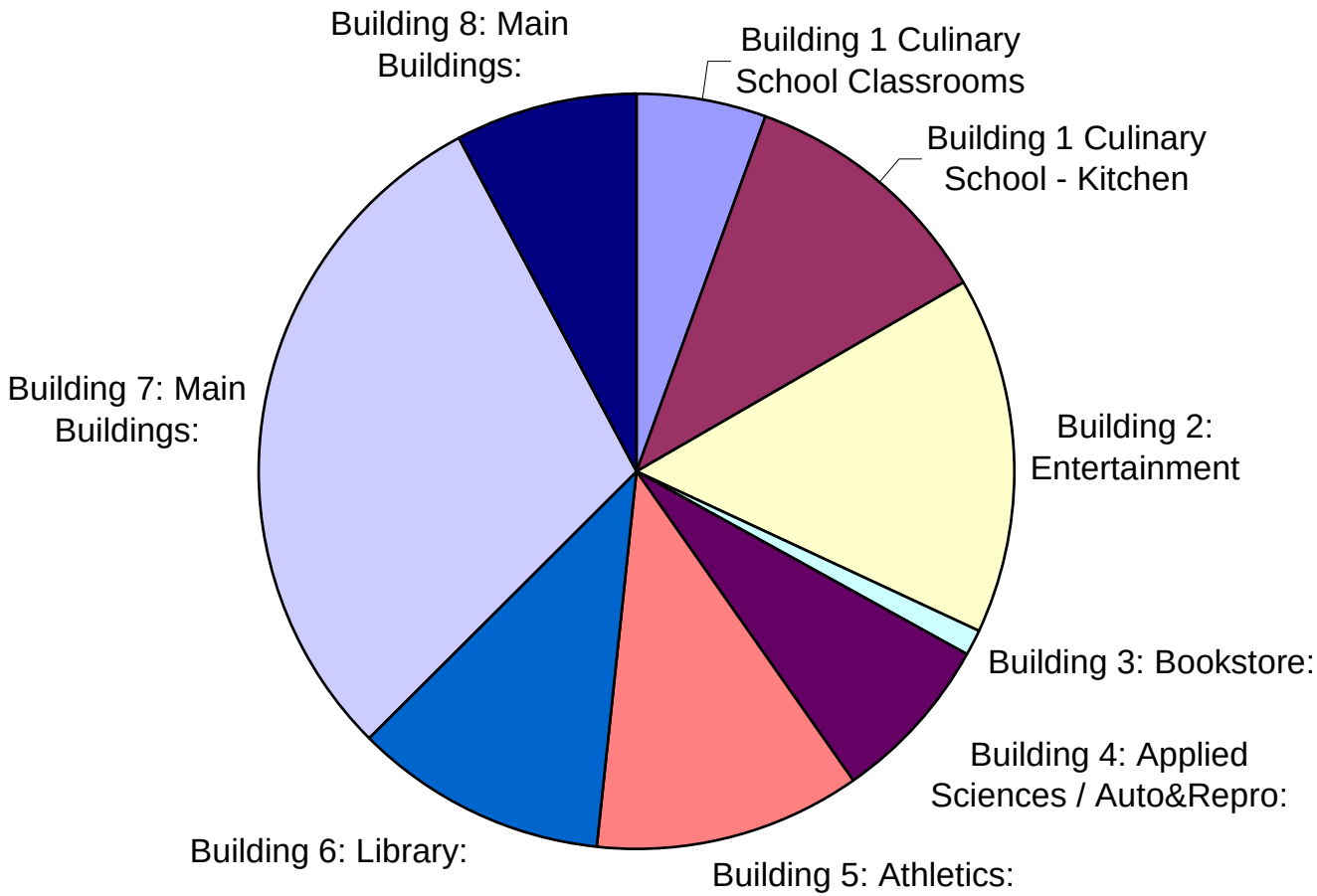
All Buildings – Total Demand



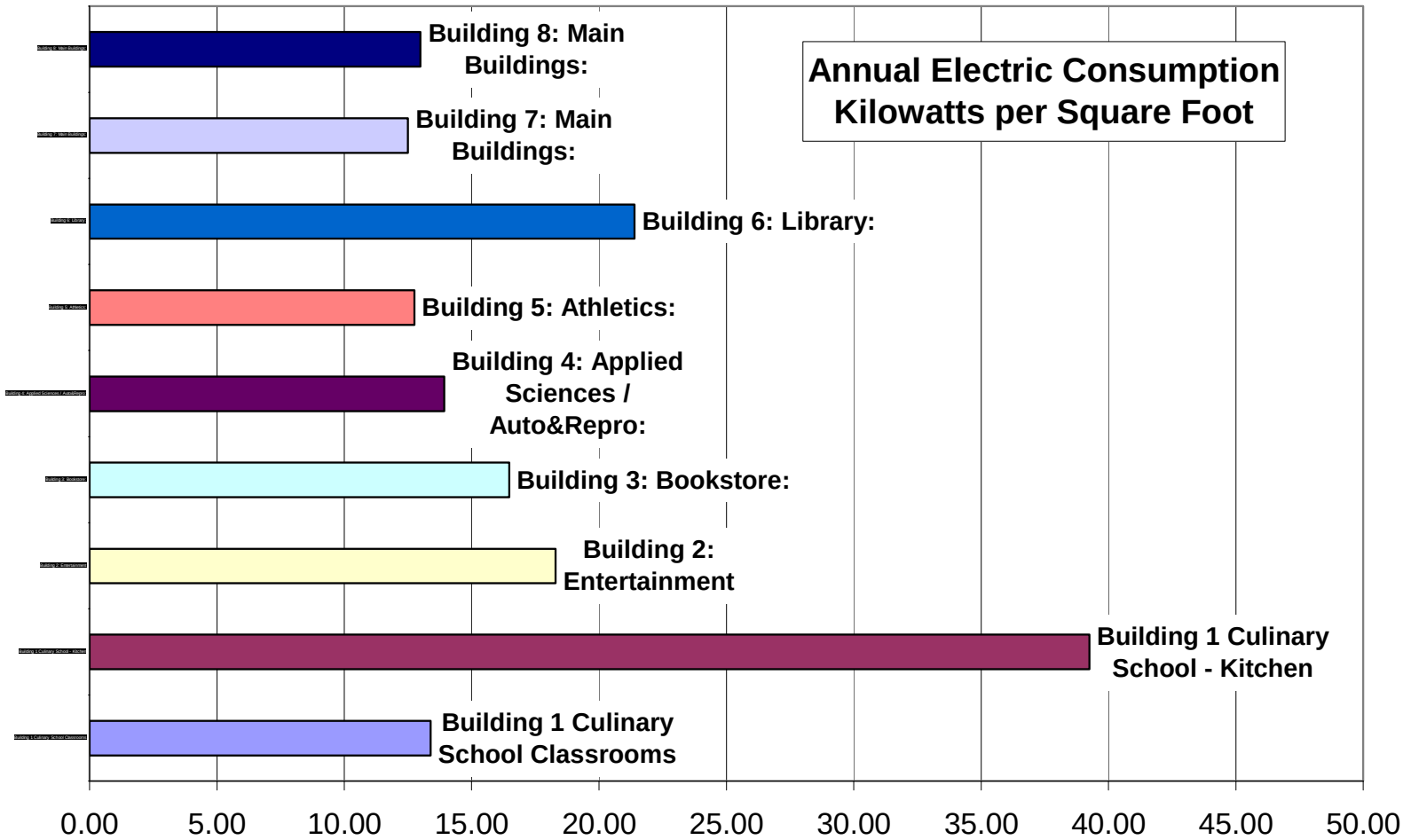
All Buildings – Total Electric Consumption



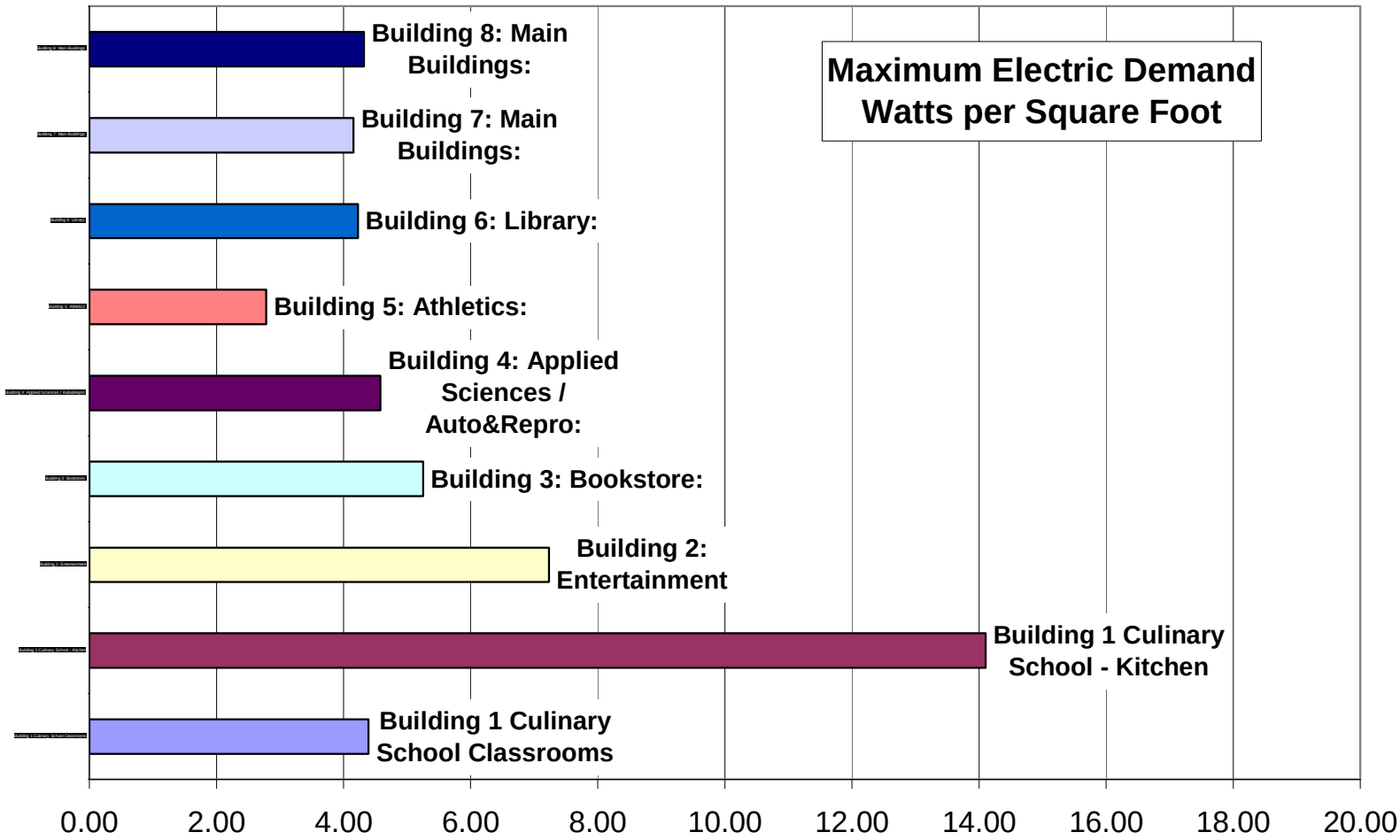
Annual Electric Consumption



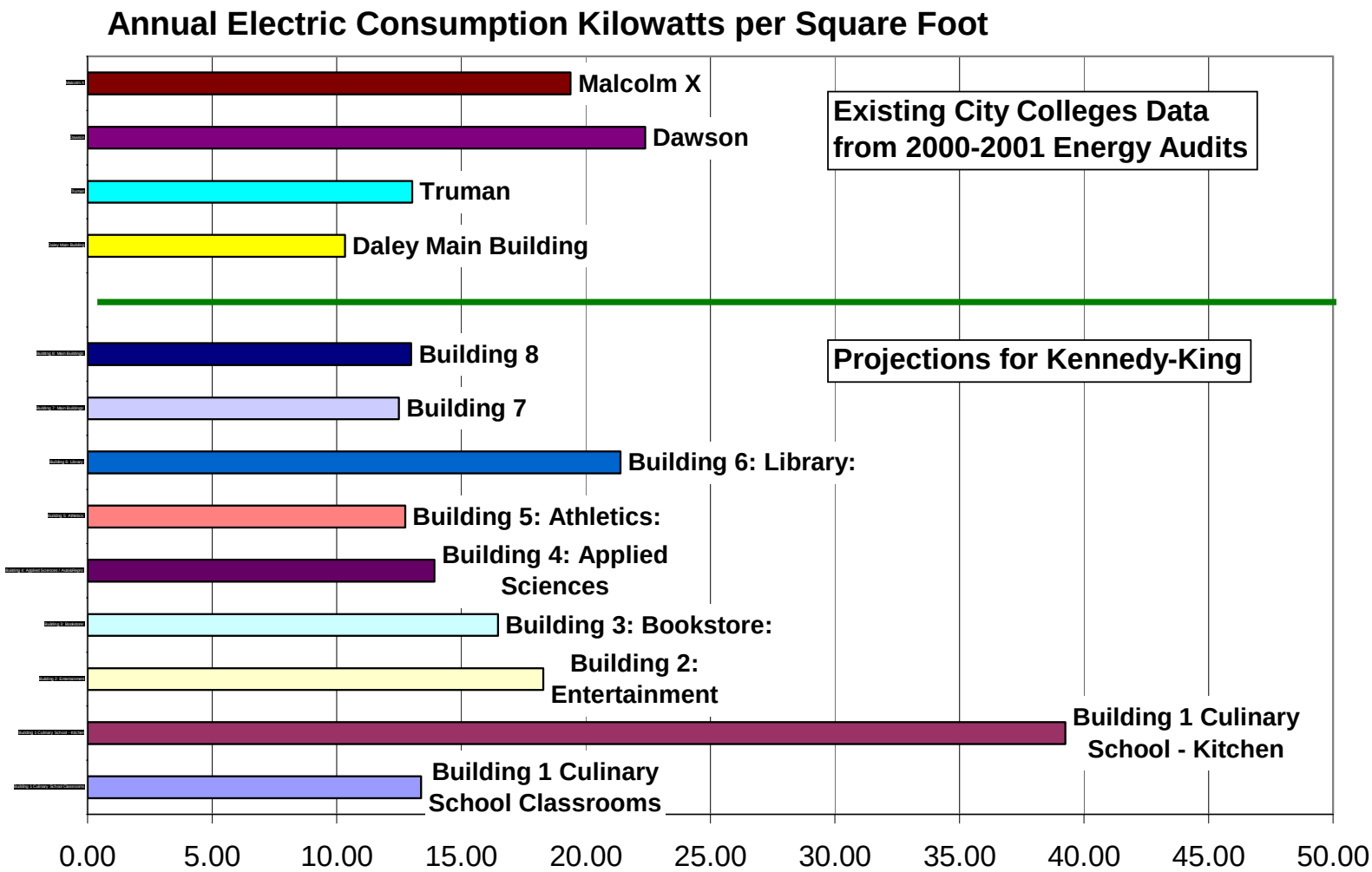
Annual Electric Consumption



Annual Electric Demand



Comparison to Existing Colleges



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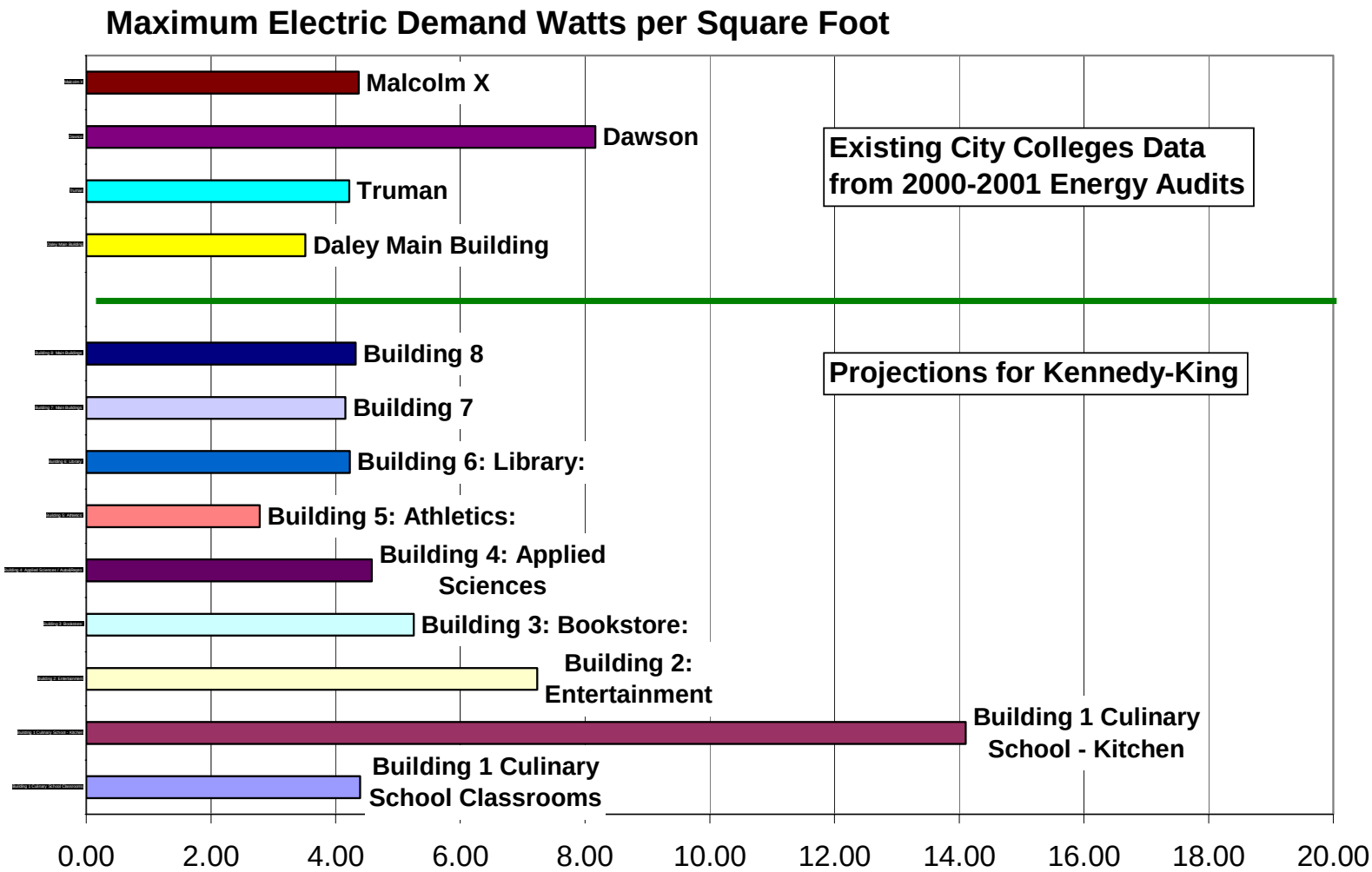
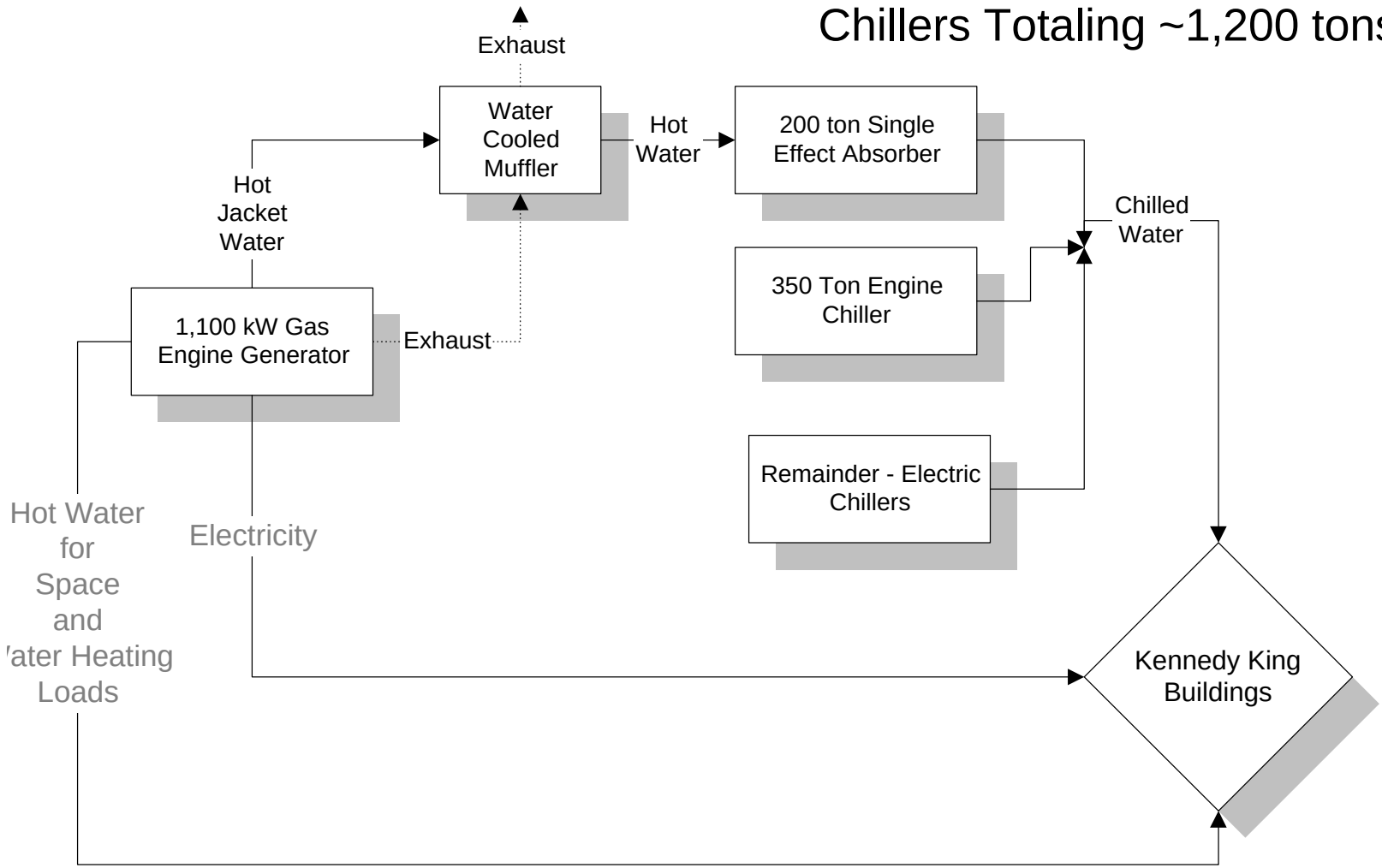


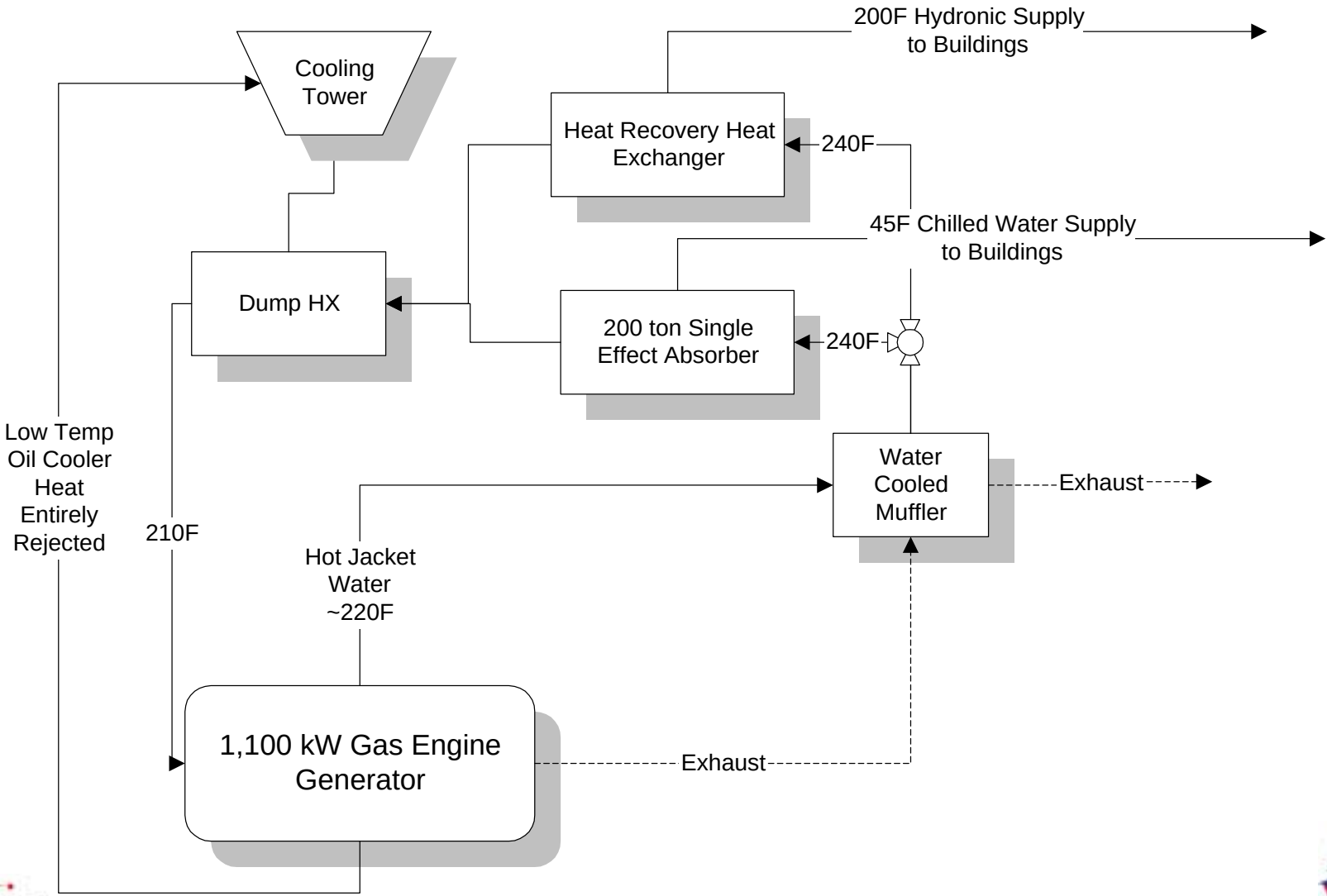
Cogeneration Concept

Engine Cogeneration Concept

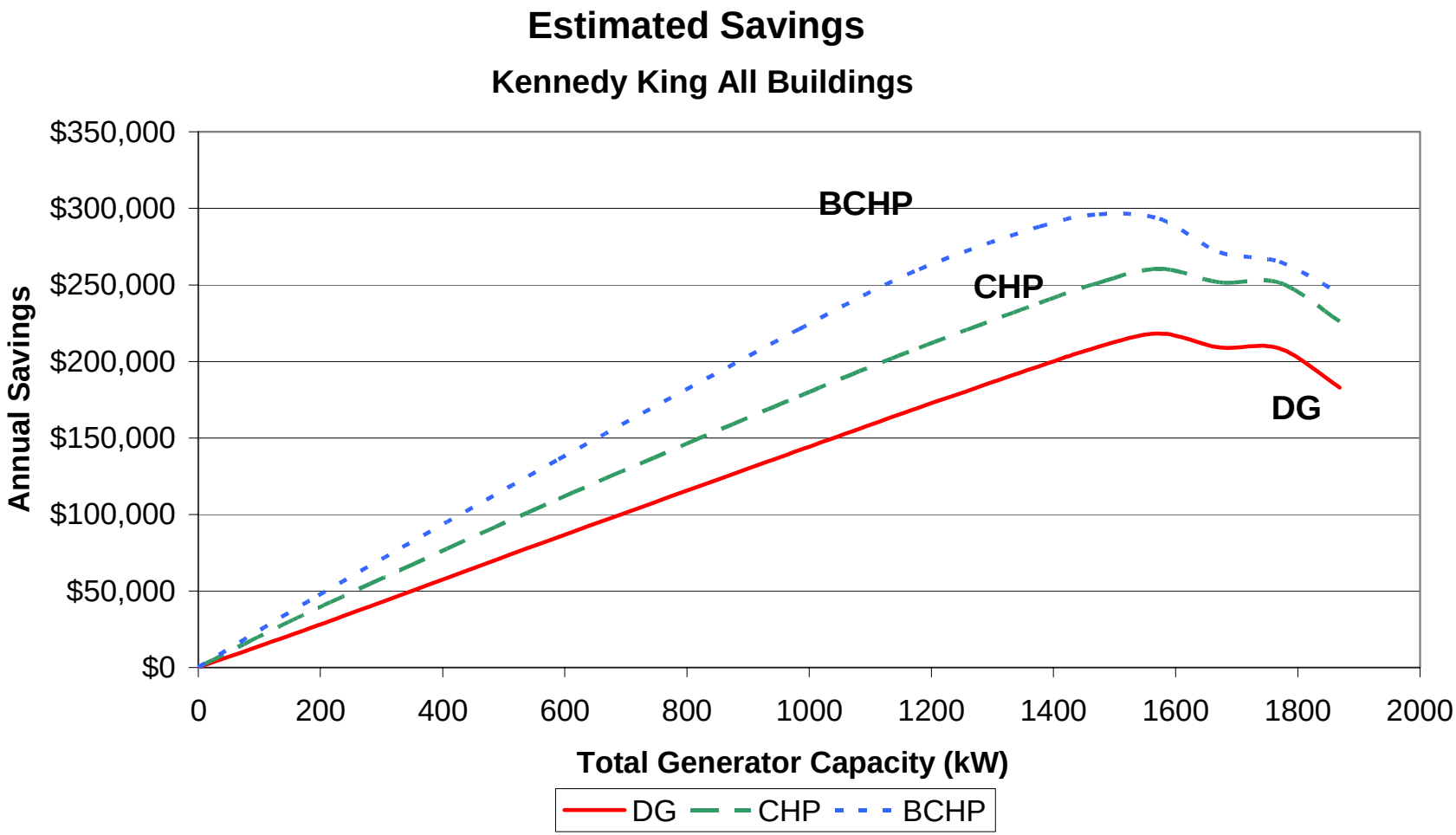
Generators Totaling 1.1 MW
Chillers Totaling ~1,200 tons



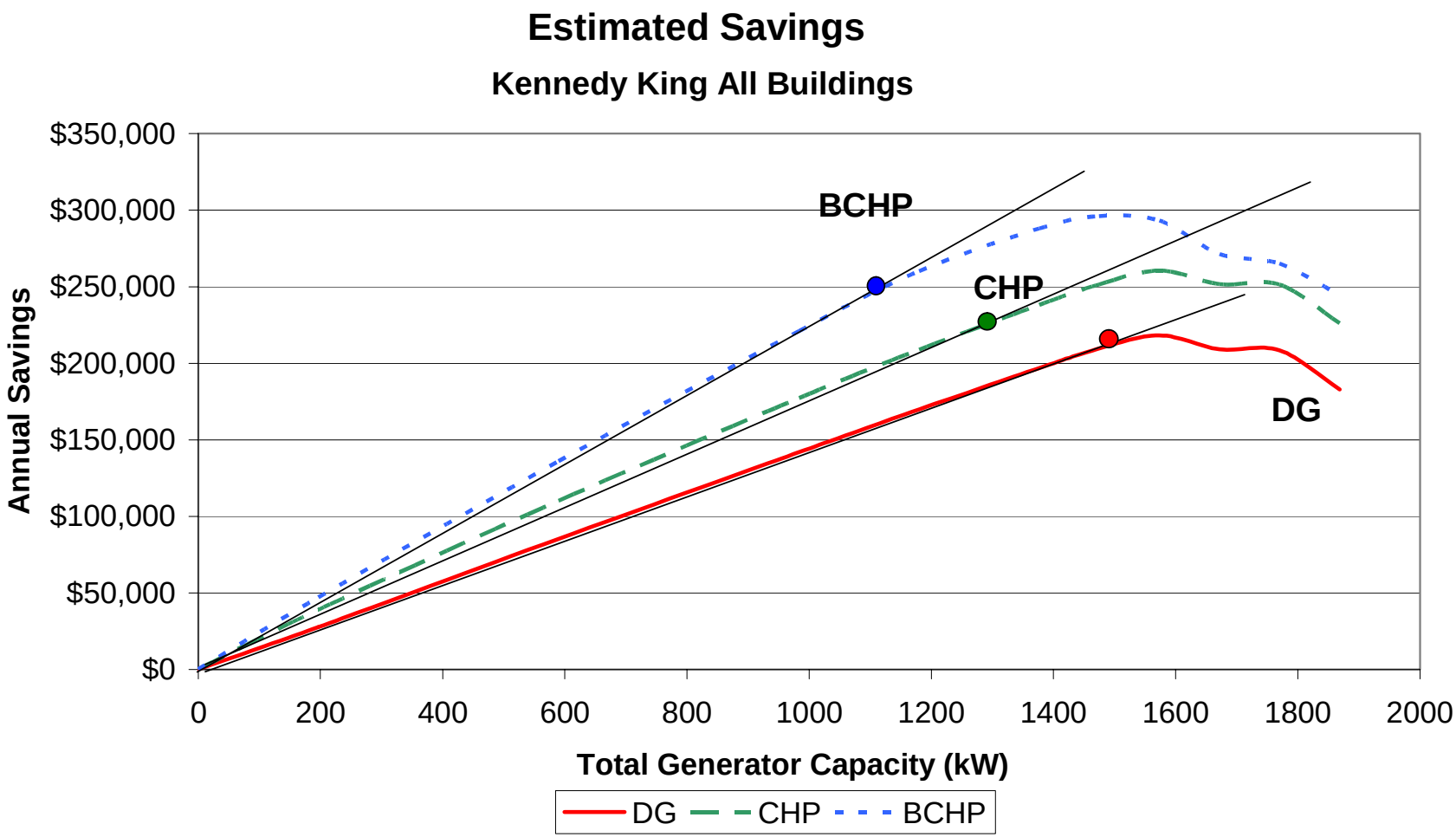
Engine Cooling Detail



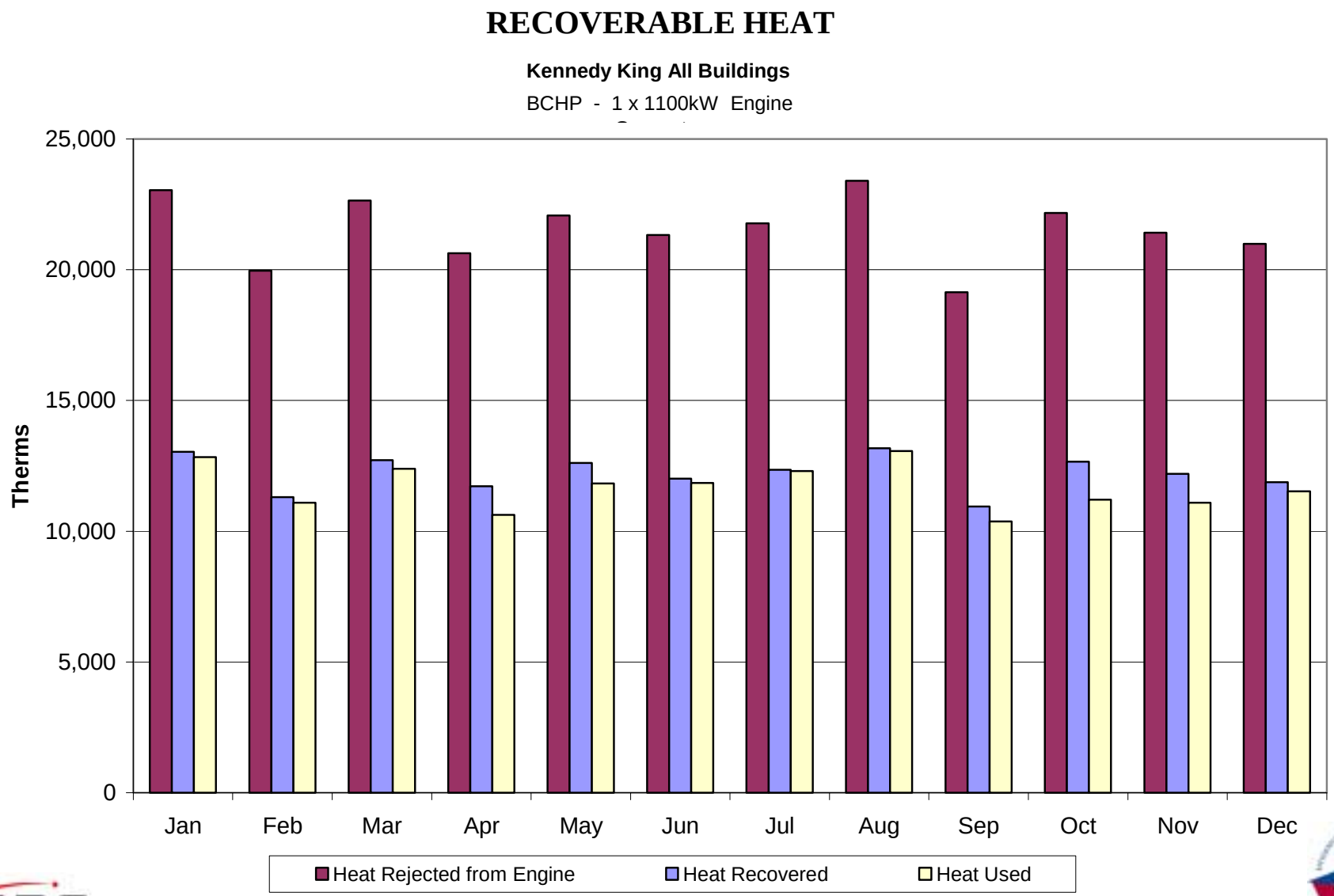
Results of the Modeling



Picking Optimum Size Points

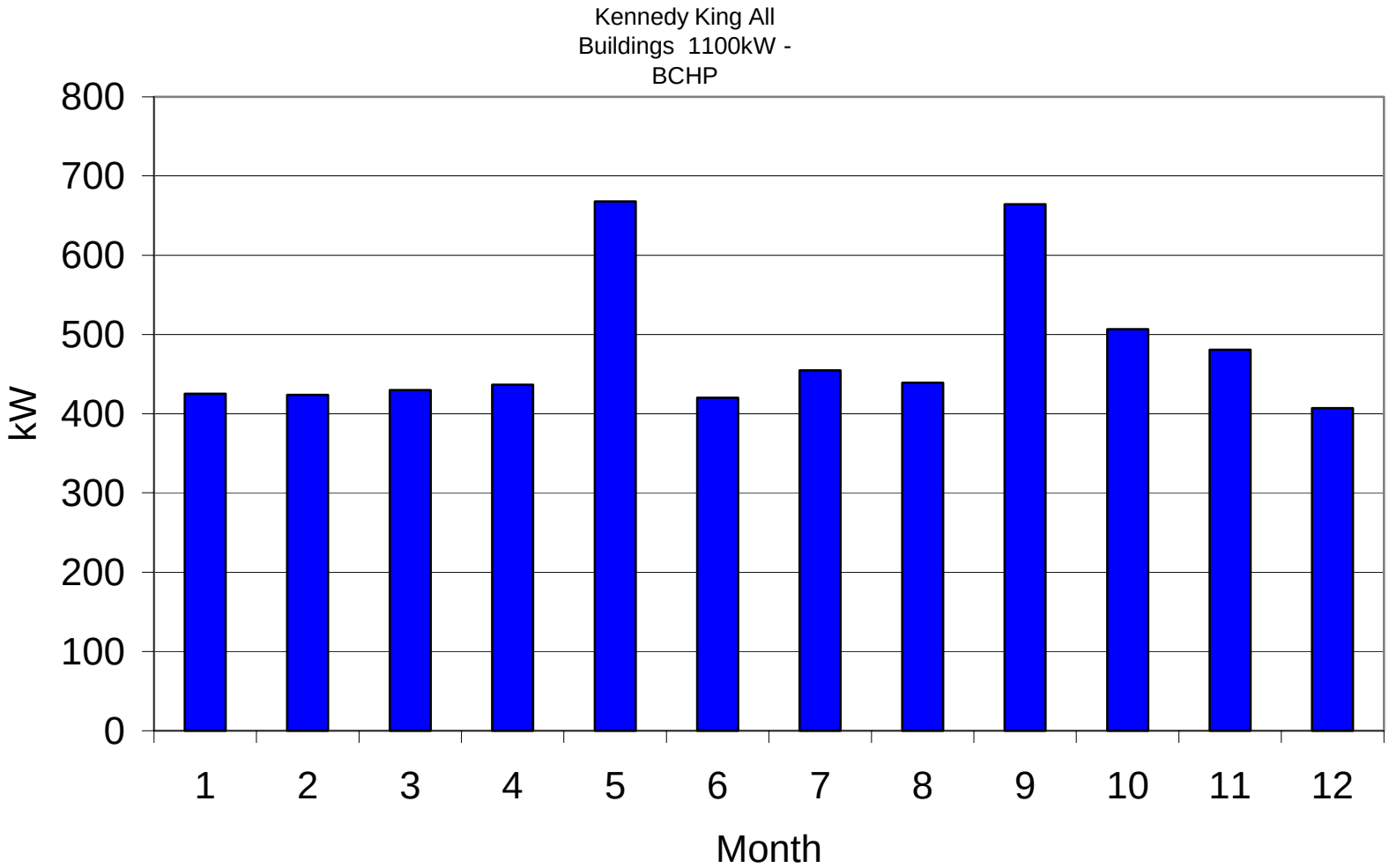


How Much Heat are We Actually Recovering



Remaining Demand with Cogeneration

Monthly Max. Demand



Values Assume Chiller Plant is All Electric Except for Heat Recovery Absorber

Pre-Concept Level First Cost Estimation

Concept			Simple Electric Chiller Plant		Gas/Electric Chiller Plant		Engine-Generator Plant		Engine-Generator Plant Heating Only		Engine-Generator Plant with Heat/Cool Cogen	
Item	Units	Cost/Unit	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Generating Equipment												
Engine Generators	per kW	$800	0	$0	0	$0	1,450	$1,160,000	1,300	$1,040,000	1,100	$880,000
switchgear	per kW	$200	0	$0	0	$0	1,450	$290,000	1,300	$260,000	1,100	$220,000
installation	per kW	$100	0	$0	0	$0	1,450	$145,000	1,300	$130,000	1,100	$110,000
Recovered Heat Driven Cooling Equipment												
Single Effect Chillers - Hot Water Fired	per ton	$600	0	$0	0	$0	0	$0	0	$0	200	$120,000
Cooling Tower and Pumps	per ton	$75	0	$0	0	$0	0	$0	0	$0	200	$15,000
Electric Service	per ton	$18	0	$0	0	$0	0	$0	0	$0	200	$3,600
Chiller Installation	per ton	$75	0	$0	0	$0	0	$0	0	$0	200	$15,000
Tower Installation	per ton	$20	0	$0	0	$0	0	$0	0	$0	200	$4,000
Tower Pumps, Piping, and Mat.	per ton	$76	0	$0	0	$0	0	$0	0	$0	200	$15,200
Gas Driven Cooling Equipment												
Engine Chillers	per ton	$500	0	$0	350	$175,000	0	$0	0	$0	0	$0
Cooling Tower and Pumps	per ton	$65	0	$0	350	$22,750	0	$0	0	$0	0	$0
Electric Service	per ton	$18	0	$0	350	$6,300	0	$0	0	$0	0	$0
Chiller Installation	per ton	$75	0	$0	350	$26,250	0	$0	0	$0	0	$0
Tower Installation	per ton	$13	0	$0	350	$4,550	0	$0	0	$0	0	$0
Tower Pumps, Piping, and Mat.	per ton	$6	0	$0	350	$2,100	0	$0	0	$0	0	$0
Electric Cooling Equipment												
Electric Chiller - High Efficiency	per ton	$250	500	$125,000	0	$0	500	$125,000	500	$125,000	300	$75,000
Electric Chiller - Low Efficiency	per ton	$200	500	$100,000	650	$130,000	500	$100,000	500	$100,000	500	$100,000
Cooling Tower and Pumps	per ton	$40	1,000	$40,000	650	$26,000	1,000	$40,000	1,000	$40,000	800	$32,000
Electric Service	per ton	$52	1,000	$52,000	650	$33,800	1,000	$52,000	1,000	$52,000	800	$41,600
Chiller Installation	per ton	$57	1,000	$57,000	650	$37,050	1,000	$57,000	1,000	$57,000	800	$45,600
Tower Installation	per ton	$13	1,000	$13,000	650	$8,450	1,000	$13,000	1,000	$13,000	800	$10,400
Tower Pumps, Piping, and Mat.	per ton	$59	1,000	$59,000	650	$38,350	1,000	$59,000	1,000	$59,000	800	$47,200
Building												
Simple Steel Clad Pre-Fab on Light Foundation	per SF	$30	7,500	$225,000	10,000	$300,000	15,000	$450,000	15,000	$450,000	15,000	$450,000
Added Foundations for Recip Engines	per Engine	$5,000	0	$0	1	$5,000	1	$5,000	1	$5,000	1	$5,000
Total				**$671,000**		**$815,600**		**$2,496,000**		**$2,331,000**		**$2,189,600**

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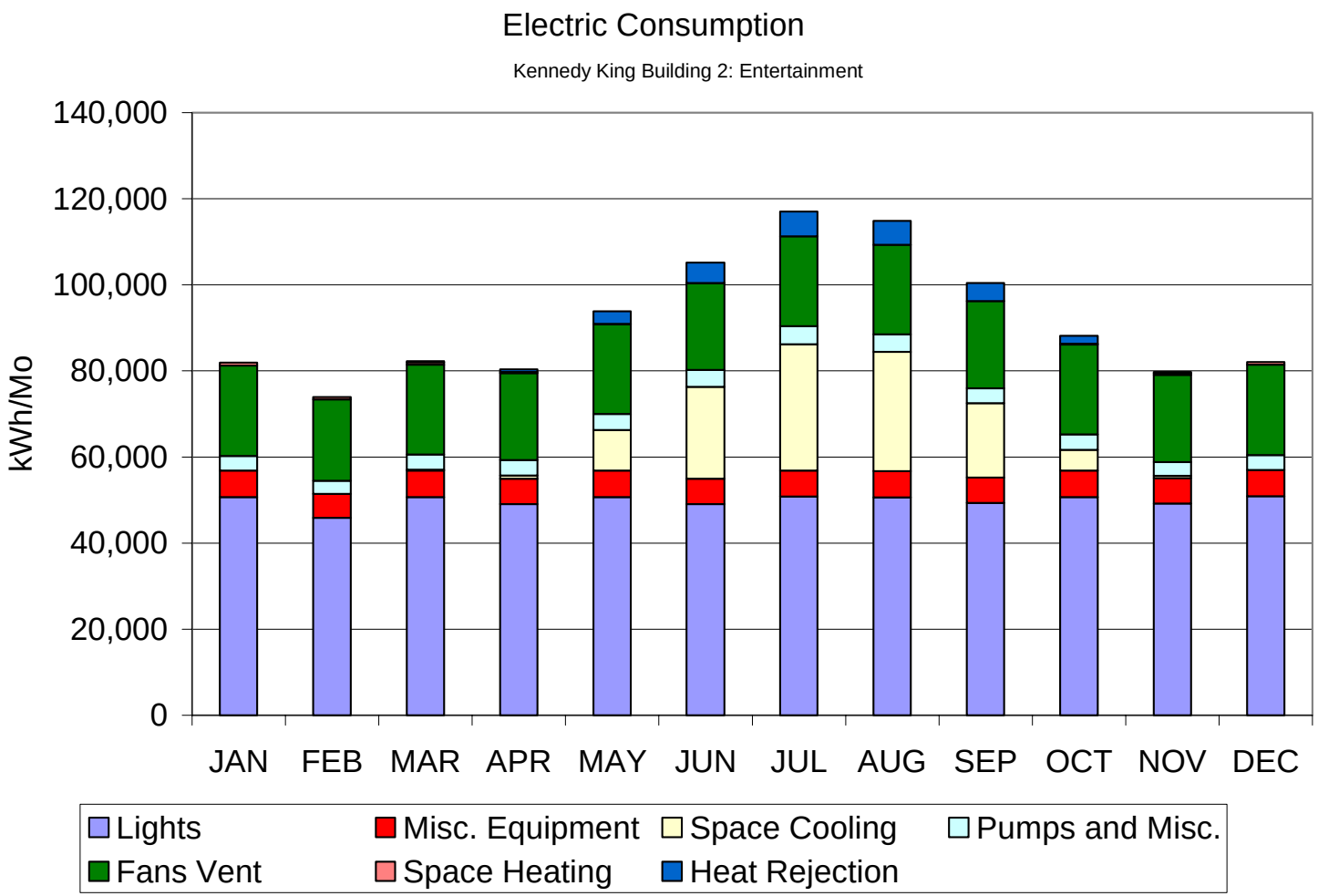
Summary

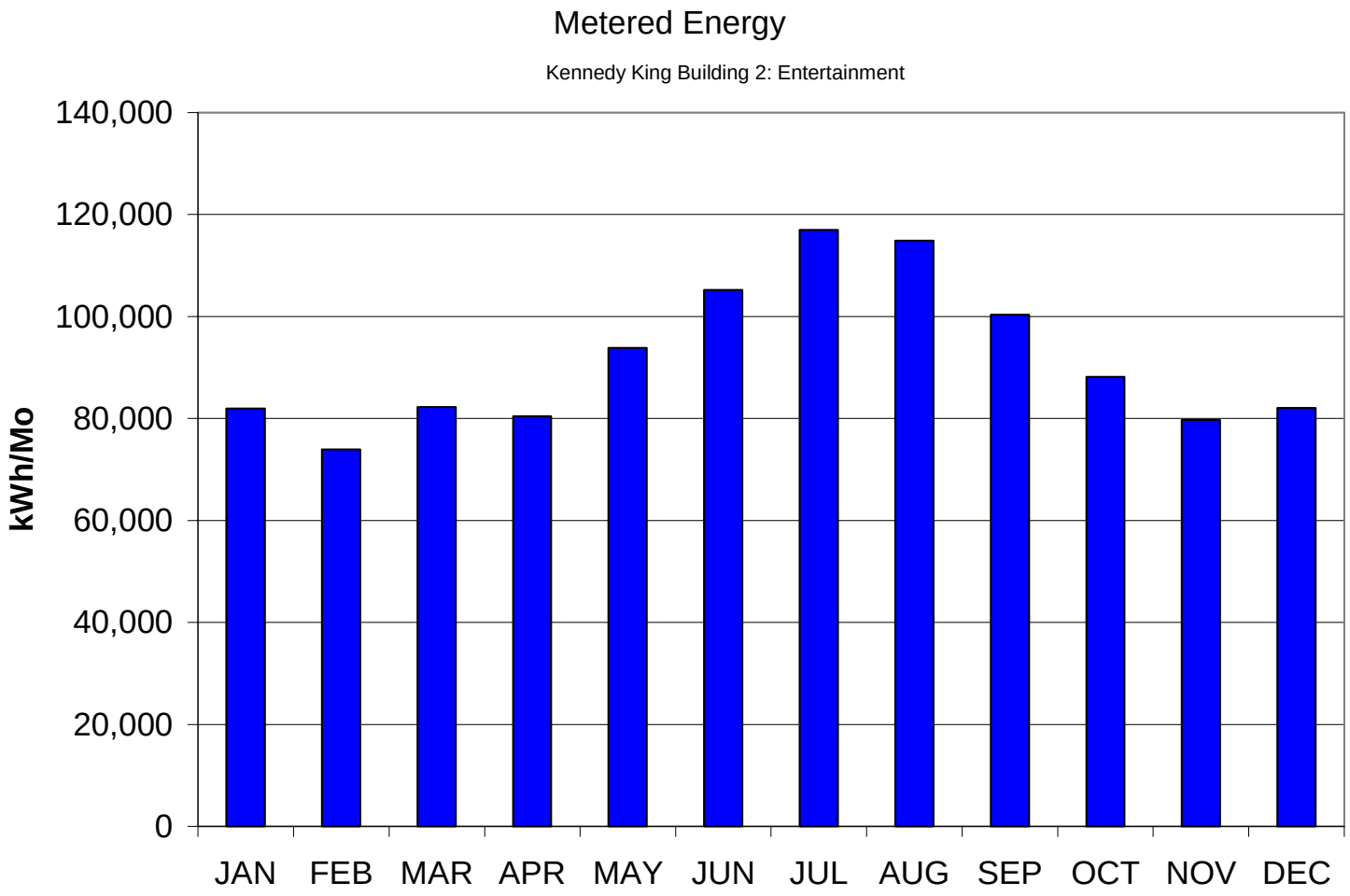
- Initial Load Done
- Concept Level Cogeneration Evaluation Done
- Evaluation and Cogeneration Design Specifics Should be Re-Done in Detail as Campus Design Progresses

Appendix

Available Information for Each Building



Available Information for Each Building



Available Information for Each Building