- Introduction
- Project History
- Existing Systems
- Improving the System
- Designing the System
- Payback Analysis
- Depth Summary
- Structural Breadth
- Construction Breadth
- Conclusions
- Q & A

david miller

MECHANICAL

unlv greenspun hall
las vegas, nevada

senior thesis presentation

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UNLV Greenspun Hall

Las Vegas, Nevada

senior thesis presentation

UNLV Greenspun Hall

Las Vegas, Nevada

project history

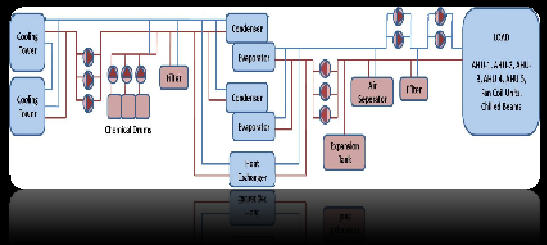
- Officially dedicated on December 2, 2008
- Classrooms and offices
- LEED Gold Certification
- Two buildings sharing a central courtyard and basement
- Design Objectives: Innovation and efficient design
- represents a commitment and investment for the future through its sustainable design and architecture

Mechanical System

System Description

existing systems

- 3 dedicated outdoor air AHU's, 5 total
- Chilled Beam distribution
- (2) Carrier 19XR Centrifugal Chillers
- (2) Marley Open Cell Cooling Towers
- Basic Heat Rejection Loop and Load Loop



Other Systems

existing systems

Structural

- Concrete structure
- Steel framing supports photovoltaic array
- Foundation – spread and strip footers
- Roof – Non composite deck on 7' joist spacing

Electrical

- Photovoltaic array – 50,000 KWh's/year
- Lighting – 1.1 watts/ft^2
- 3 distribution panels – total = 2,200 amps

Goal:

make a LEED Gold building better

improving the system

3 Alternatives

(1) Replace existing chillers w/ absorption chillers
Solar absorber array to drive generators

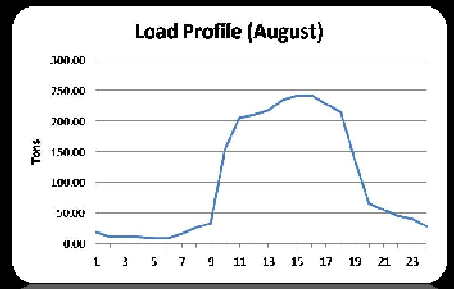
(2) Add chilled water storage to Alternative 1

(3) Add chilled water storage to existing system

Procedure

improving the system

- Load profiles taken from TRACE 700 calc
- Simplify the calculation
  - Every month has a typical day
  - Every typical day has a load profile and TMY data
- Used to calculate existing system (control) and alternative's annual regulated energy costs



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Control

designing the system

- Convert Load Profiles to KW's using chiller η
  - 0.837 KW/ton
- Use consumption and demand charges to calculate annual cost ~ $35,000

Electric Charge		Summer	All Other Periods
Consumption	On-Peak	$0.10001	$0.06406
	Mid-Peak	$0.0865	
	Off-Peak	$0.06230	
Demand	On-Peak	$9.17	$0.50
	Mid-Peak	$0.68	
	Off-Peak	$0.00	

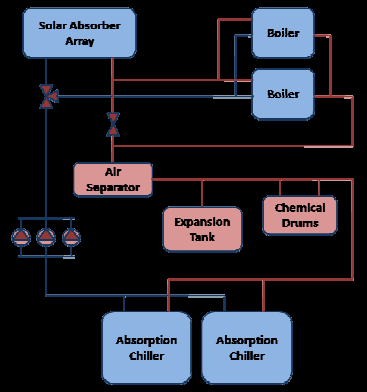
Cooling Load (tons) vs. Hour/day

	J	F	M	A	M	J	J	A	S	O	N	D
0:01 - 1:00	0	0	0	0	0	17.39	17.91	19.33	15.93	0	0	0
1:01 - 2:00	0	0	0	0	0	10.87	11.2	12.08	9.96	0	0	0
2:01 - 3:00	0	0	0	0	0	10.87	11.2	12.08	9.96	0	0	0
3:01 - 4:00	0	0	0	0	0	10.87	11.2	12.08	9.96	0	0	0
4:01 - 5:00	0	0	0	0	0	8.69	8.96	9.66	7.97	0	0	0
5:01 - 6:00	0	0	0	0	0	8.69	8.96	9.66	7.97	0	0	0
6:01 - 7:00	0	0	0	0	0	15.22	15.67	16.91	13.94	0	0	0
7:01 - 8:00	6.62	5.99	6.37	5.62	6.39	23.91	24.63	26.57	21.91	6.7	6.18	6.29
8:01 - 9:00	8.43	7.62	8.11	7.16	8.13	30.43	31.35	33.82	27.88	8.53	7.87	8.01
9:01 - 10:00	38.52	34.85	37.07	32.72	37.19	139.11	143.31	154.6	127.45	38.97	35.98	36.61
10:01 - 11:00	51.16	46.28	49.23	43.46	49.39	184.76	190.33	205.33	169.27	51.76	47.79	48.62
11:01 - 12:00	52.37	47.37	50.39	44.48	50.55	189.11	194.81	210.16	173.26	52.98	48.91	49.77
12:01 - 13:00	54.17	49	52.13	46.02	52.3	195.63	201.53	217.41	179.23	54.8	50.6	51.48
13:01 - 14:00	58.39	52.81	56.18	49.59	56.36	210.84	217.2	234.32	193.17	59.07	54.53	55.49
14:01 - 15:00	60.19	54.45	57.92	51.13	58.11	217.37	223.92	241.57	199.14	60.89	56.22	57.2
15:01 - 16:00	60.19	54.45	57.92	51.13	58.11	217.37	223.92	241.57	199.14	60.89	56.22	57.2
16:01 - 17:00	56.58	51.18	54.44	48.06	54.62	204.32	210.49	227.07	187.2	57.24	52.85	53.77
17:01 - 18:00	53.57	48.46	51.55	45.5	51.71	193.46	199.29	214.99	177.24	54.2	50.04	50.91
18:01 - 19:00	34.31	31.03	33.01	29.14	33.12	123.9	127.64	137.69	113.51	34.71	32.05	32.61
19:01 - 20:00	16.25	14.7	15.64	13.8	15.69	58.69	60.46	65.22	53.77	16.44	15.18	15.44
20:01 - 21:00	13.84	12.52	13.32	11.76	13.36	49.99	51.5	55.56	45.8	14.01	12.93	13.16
21:01 - 22:00	11.44	10.34	11	9.71	11.04	41.3	42.55	45.9	37.84	11.57	10.68	10.87
22:01 - 23:00	10.23	9.26	9.85	8.69	9.88	36.95	38.07	41.07	33.85	10.35	9.56	9.72
23:01 - 24:00	0	0	0	0	0	26.08	26.87	28.99	23.9	0	0	0

Alternative 1

designing the system

- (2) Single Effect Absorption Chillers
- Solar absorber array
- (2) Back-up Boilers



Alternative 1

designing the system

- Solar absorber array can sufficiently maintain the hot water temperature needed to drive the generators
- 425 absorbers = 17,000 ft^2
- Boilers only needed when the sun isn't shining
- System consumes natural gas instead of electricity

Average Hourly Statistics for Direct Normal Solar Radiation Wh/m²

Hour	J	F	M	A	M	J	J	A	S	O	N	D
0:01 - 1:00	0	0	0	0	0	0	0	0	0	0	0	0
1:01 - 2:00	0	0	0	0	0	0	0	0	0	0	0	0
2:01 - 3:00	0	0	0	0	0	0	0	0	0	0	0	0
3:01 - 4:00	0	0	0	0	0	0	0	0	0	0	0	0
4:01 - 5:00	0	0	0	1	42	69	42	2	0	0	0	0
5:01 - 6:00	0	0	16	185	340	429	347	253	90	23	0	0
6:01 - 7:00	0	68	244	501	535	640	605	551	452	381	161	27
7:01 - 8:00	302	348	457	674	687	736	726	701	644	646	481	371
8:01 - 9:00	510	523	545	720	777	784	755	780	695	730	607	549
9:01 - 10:00	588	606	593	770	798	752	797	807	798	767	689	613
10:01 - 11:00	655	679	588	769	761	791	810	815	833	748	697	687
11:01 - 12:00	642	630	615	766	679	760	820	812	817	780	735	676
12:01 - 13:00	598	662	641	714	689	770	802	752	817	756	724	675
13:01 - 14:00	577	620	578	673	718	759	775	682	752	696	696	658
14:01 - 15:00	564	543	554	649	690	703	756	658	641	675	629	602
15:01 - 16:00	476	443	429	607	658	698	686	585	604	596	463	406
16:01 - 17:00	144	265	314	470	585	606	614	534	441	323	117	44
17:01 - 18:00	0	15	108	266	352	435	494	369	160	13	0	0
18:01 - 19:00	0	0	0	17	46	152	182	53	0	0	0	0
19:01 - 20:00	0	0	0	0	0	0	0	0	0	0	0	0
20:01 - 21:00	0	0	0	0	0	0	0	0	0	0	0	0
21:01 - 22:00	0	0	0	0	0	0	0	0	0	0	0	0
22:01 - 23:00	0	0	0	0	0	0	0	0	0	0	0	0
23:01 - 24:00	0	0	0	0	0	0	0	0	0	0	0	0

Alternative 1

designing the system

❖Annual Regulated Energy Cost

Chiller Output

$\eta_{chiller}$

Generator Input = Boiler Output

η_{boiler}

Boiler Input

Gas Firing Rate (CHF) of Boiler vs. Hour/day

Hour	J	F	M	A	M	J	J	A	S	O	N	D
0:01 - 1:00	0	0	0	0	0	376.04	387.38	417.91	344.52	0	0	0
1:01 - 2:00	0	0	0	0	0	235.03	242.12	261.19	215.32	0	0	0
2:01 - 3:00	0	0	0	0	0	235.03	242.12	261.19	215.32	0	0	0
3:01 - 4:00	0	0	0	0	0	235.03	242.12	261.19	215.32	0	0	0
4:01 - 5:00	0	0	0	0	0	188.02	193.69	208.96	172.26	0	0	0
5:01 - 6:00	0	0	0	0	0	188.02	193.69	208.96	172.26	0	0	0
6:01 - 7:00	0	0	0	0	0	0	0	0	250.96	0	0	0
7:01 - 8:00	143.18	129.51	105.93	0	0	0	0	0	0	0	62.71	136.07
8:01 - 9:00	21.66	0	0	0	0	0	0	0	0	0	0	0
9:01 - 10:00	0	0	0	0	0	0	0	0	0	0	0	0
10:01 - 11:00	0	0	0	0	0	0	0	0	0	0	0	0
11:01 - 12:00	0	0	0	0	0	0	0	0	0	0	0	0
12:01 - 13:00	0	0	0	0	0	0	0	0	0	0	0	0
13:01 - 14:00	0	0	0	0	0	0	0	0	0	0	0	0
14:01 - 15:00	0	0	0	0	0	0	0	0	0	0	0	0
15:01 - 16:00	690.7	1116.28	0	0	0	0	0	0	0	0	842.53	1237.01
16:01 - 17:00	1223.57	1106.75	1177.35	629.02	0	0	0	0	3942.67	1237.82	1142.84	1162.79
17:01 - 18:00	1158.49	1047.88	1114.73	984.04	1118.33	4183.47	4309.66	4649.26	3832.77	1171.98	1082.05	1100.94
18:01 - 19:00	741.95	671.11	713.93	630.23	716.24	2679.3	2760.12	2977.62	2454.7	750.59	693	705.1
19:01 - 20:00	351.45	317.9	338.18	298.53	339.27	1269.14	1307.42	1410.45	1162.75	355.54	328.26	333.99
20:01 - 21:00	299.38	270.8	288.08	254.3	289.01	1081.12	1113.73	1201.49	990.49	302.87	279.63	284.51
21:01 - 22:00	247.32	223.7	237.98	210.08	238.75	893.1	920.04	992.54	818.23	250.2	231	235.03
22:01 - 23:00	221.28	200.16	212.93	187.96	213.61	799.09	823.19	888.06	732.1	223.86	206.68	210.29
23:01 - 24:00	0	0	0	0	0	564.06	581.08	626.87	516.78	0	0	0

Alternative 1

designing the system

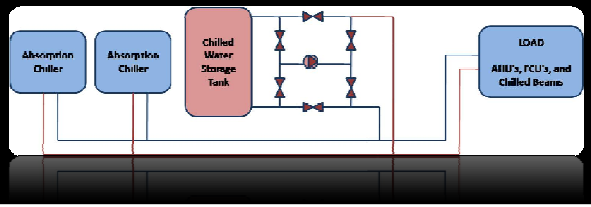
- Regulated Energy Cost $11,370
- Additional Pumping Cost $3,760
- Total Annual Operating Cost $15,130

Natural Gas Cost Analysis												
Month	J	F	M	A	M	J	J	A	S	O	N	D
Days	31	28	31	30	31	30	31	31	30	31	30	31
Therm/day	5.1	5.08	4.19	3.19	2.92	12.9	13.3	14.37	16.04	4.29	4.87	5.41
Therm/month	158.07	142.35	130	95.8	90.4	388	413	445.34	481.09	133.08	146	168
Cost/Therm	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Cost/Month	155.41	139.96	128	94.2	88.9	381	406	437.84	472.99	130.84	144	165
Base/Month	30	30	30	30	30	30	30	30	30	30	30	30
Total/Month	185.41	169.96	158	124	119	411	436	467.84	502.99	160.84	174	195
Total	3103.24											
Existing Pump Cost	8265.62											
Additional Pump Cost	3760											
Total System Cost	$15,128.86											

Alternative 2

designing the system

- (2) Single Effect Absorption Chillers
- Solar absorber array
- (2) Back-up Boilers
- Chilled Water Storage



Alternative 2

designing the system

❖Sizing Strategy: assist absorber array during peak loading to reduce the volume of the array

❖Not economical to utilize thermal storage for non-peak months

❖900 ton tank, direct interface

$$V_{gal} = \frac{1440 \times S[ton-h]}{FoM \times \Delta T}$$

~76,000 gallons

❖Reduced Solar Array

$$\frac{Q_1}{Q_2} = \frac{V_1}{V_2}$$

❖290 absorbers

❖Eliminates 135 absorbers and 5,400 ft^2 of roof space

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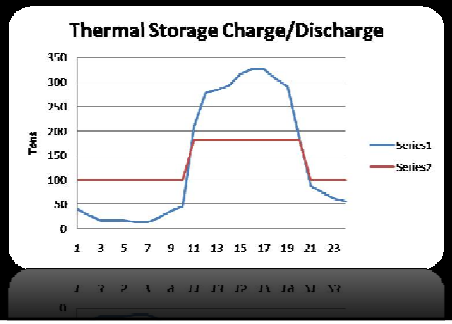
Alternative 2

designing the system

❖Charging and Discharging



Without Storage

Cooling Load (tons) vs. Hour/day

Hour	J	J	A	S
0:01 - 1:00	17.39	17.91	19.33	15.93
1:01 - 2:00	10.87	11.2	12.08	9.96
2:01 - 3:00	10.87	11.2	12.08	9.96
3:01 - 4:00	10.87	11.2	12.08	9.96
4:01 - 5:00	8.69	8.96	9.66	7.97
5:01 - 6:00	8.69	8.96	9.66	7.97
6:01 - 7:00	15.22	15.67	16.91	13.94
7:01 - 8:00	23.91	24.63	26.57	21.91
8:01 - 9:00	30.43	31.35	33.82	27.88
9:01 - 10:00	139.11	143.31	154.6	127.45
10:01 - 11:00	184.76	190.33	205.33	169.27
11:01 - 12:00	189.11	194.81	210.16	173.26
12:01 - 13:00	195.63	201.53	217.41	179.23
13:01 - 14:00	210.84	217.2	234.32	193.17
14:01 - 15:00	217.37	223.92	241.57	199.14
15:01 - 16:00	217.37	223.92	241.57	199.14
16:01 - 17:00	204.32	210.49	227.07	187.2
17:01 - 18:00	193.46	199.29	214.99	177.24
18:01 - 19:00	123.9	127.64	137.69	113.51
19:01 - 20:00	58.69	60.46	65.22	53.77
20:01 - 21:00	49.99	51.5	55.56	45.8
21:01 - 22:00	41.3	42.55	45.9	37.84
22:01 - 23:00	36.95	38.07	41.07	33.85
23:01 - 24:00	26.08	26.87	28.99	23.9

With Storage

Cooling Load (tons) vs. Hour/day

Hour	J	J	A	S
0:01 - 1:00	100	100	100	100
1:01 - 2:00	100	100	100	100
2:01 - 3:00	100	100	100	100
3:01 - 4:00	100	100	100	100
4:01 - 5:00	100	100	100	100
5:01 - 6:00	100	100	100	100
6:01 - 7:00	100	100	100	100
7:01 - 8:00	100	100	100	100
8:01 - 9:00	100	100	100	100
9:01 - 10:00	39.11	43.31	54.6	27.45
10:01 - 11:00	84.76	90.33	105.33	69.27
11:01 - 12:00	89.11	94.81	110.16	73.26
12:01 - 13:00	95.63	101.53	117.41	79.23
13:01 - 14:00	110.84	117.2	134.32	93.17
14:01 - 15:00	117.37	123.92	141.57	99.14
15:01 - 16:00	117.37	123.92	141.57	99.14
16:01 - 17:00	104.32	110.49	127.07	87.2
17:01 - 18:00	93.46	99.29	114.99	77.24
18:01 - 19:00	123.9	127.64	137.69	113.51
19:01 - 20:00	58.69	60.46	65.22	53.77
20:01 - 21:00	49.99	51.5	55.56	45.8
21:01 - 22:00	41.3	42.55	45.9	37.84
22:01 - 23:00	100	100	100	100
23:01 - 24:00	100	100	100	100

designing the system

Alternative 2

- ❖Regulated Energy Cost $12,825
- ❖Additional Pumping Cost $1,880
- ❖Charge/Discharge Tank $2,940
- ❖Total Annual Operating Cost $17,645

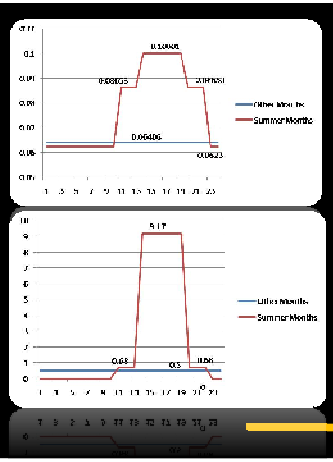
Natural Gas Cost Analysis

Month	J	F	M	A	M	J	J	A	S	O	N	D
Days	31	28	31	30	31	30	31	31	30	31	30	31
Therm/day	5.1	5.08	4.19	3.19	2.92	25.24	25.55	26.37	28.03	4.29	4.87	5.41
Therm/month	158.06	142.36	129.86	95.81	90.37	757.31	792.01	817.43	841	133.08	146.06	167.57
Cost/Therm	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Cost/Month	155.4	139.96	127.67	94.2	88.84	744.56	778.67	803.66	826.84	130.84	143.6	164.75
Base/Month	30	30	30	30	30	30	30	30	30	30	30	30
Total/Month	185.4	169.96	157.67	124.2	118.84	774.56	808.67	833.66	856.84	160.84	173.6	194.75
Total	4559											
Existing Pump Cost	8265.62											
Additional Pump Cost	4820											
Total System Cost	$17,644.62											

Alternative 3

designing the system

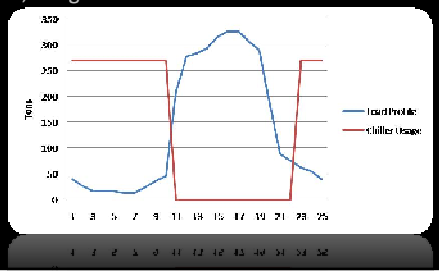
- Existing Centrifugal Chillers
- Chilled Water Storage
- 2 sizing strategies
  - 12 hour charge / 12 hour discharge
  - 12 hour charge / 6 hour discharge



Alternative 3

designing the system

- 12 hour charge, 12 hour discharge
- 2,900 ton tank, direct interface
~246,000 gallons



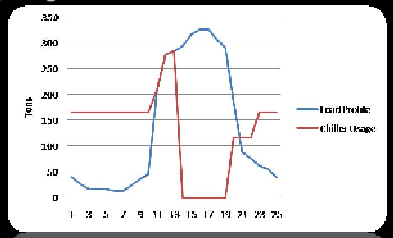
Chiller Output (tons) vs. Hour/day

Hour	J	F	M	A	M	J	J	A	S	O	N	D
0:01 - 1:00	0	0	0	0	0	270	270	270	270	0	0	0
1:01 - 2:00	0	0	0	0	0	270	270	270	270	0	0	0
2:01 - 3:00	0	0	0	0	0	270	270	270	270	0	0	0
3:01 - 4:00	0	0	0	0	0	270	270	270	270	0	0	0
4:01 - 5:00	0	0	0	0	0	270	270	270	270	0	0	0
5:01 - 6:00	0	0	0	0	0	270	270	270	270	0	0	0
6:01 - 7:00	0	0	0	0	0	270	270	270	270	0	0	0
7:01 - 8:00	6.6	6	6.4	5.6	6.4	270	270	270	270	6.7	6.2	6.3
8:01 - 9:00	8.4	7.6	8.1	7.2	8.1	270	270	270	270	8.5	7.9	8
9:01 - 10:00	39	35	37	33	37	0	0	0	0	39	36	37
10:01 - 11:00	51	46	49	43	49	0	0	0	0	52	48	49
11:01 - 12:00	52	47	50	44	51	0	0	0	0	53	49	50
12:01 - 13:00	54	49	52	46	52	0	0	0	0	55	51	51
13:01 - 14:00	58	53	56	50	56	0	0	0	0	59	55	55
14:01 - 15:00	60	54	58	51	58	0	0	0	0	61	56	57
15:01 - 16:00	60	54	58	51	58	0	0	0	0	61	56	57
16:01 - 17:00	57	51	54	48	55	0	0	0	0	57	53	54
17:01 - 18:00	54	48	52	46	52	0	0	0	0	54	50	51
18:01 - 19:00	34	31	33	29	33	0	0	0	0	35	32	33
19:01 - 20:00	16	15	16	14	16	0	0	0	0	16	15	15
20:01 - 21:00	14	13	13	12	13	0	0	0	0	14	13	13
21:01 - 22:00	11	10	11	9.7	11	270	270	270	270	12	11	11
22:01 - 23:00	10	9.3	9.9	8.7	9.9	270	270	270	270	10	9.6	9.7
23:01 - 24:00	0	0	0	0	0	270	270	270	270	0	0	0

Alternative 3

designing the system

- 12 hour charge, 6 hour discharge
- 1,800 ton tank, direct interface
~153,000 gallons



Chiller Output (tons) vs. Hour/day

Hour	J	F	M	A	M	J	J	A	S	O	N	D
0:01 - 1:00	0	0	0	0	0	165	165	165	165	0	0	0
1:01 - 2:00	0	0	0	0	0	165	165	165	165	0	0	0
2:01 - 3:00	0	0	0	0	0	165	165	165	165	0	0	0
3:01 - 4:00	0	0	0	0	0	165	165	165	165	0	0	0
4:01 - 5:00	0	0	0	0	0	165	165	165	165	0	0	0
5:01 - 6:00	0	0	0	0	0	165	165	165	165	0	0	0
6:01 - 7:00	0	0	0	0	0	165	165	165	165	0	0	0
7:01 - 8:00	6.62	5.99	6.37	5.62	6.39	165	165	165	165	6.7	6.18	6.29
8:01 - 9:00	8.43	7.62	8.11	7.16	8.13	165	165	165	165	8.53	7.87	8.01
9:01 - 10:00	38.52	34.85	37.07	32.72	37.19	139.11	143.31	154.6	127.45	38.97	35.98	36.61
10:01 - 11:00	51.16	46.28	49.23	43.46	49.39	184.76	190.33	205.33	169.27	51.76	47.79	48.62
11:01 - 12:00	52.37	47.37	50.39	44.48	50.55	189.11	194.81	210.16	173.26	52.98	48.91	49.77
12:01 - 13:00	54.17	49	52.13	46.02	52.3	0	0	0	0	54.8	50.6	51.48
13:01 - 14:00	58.39	52.81	56.18	49.59	56.36	0	0	0	0	59.07	54.53	55.49
14:01 - 15:00	60.19	54.45	57.92	51.13	58.11	0	0	0	0	60.89	56.22	57.2
15:01 - 16:00	60.19	54.45	57.92	51.13	58.11	0	0	0	0	60.89	56.22	57.2
16:01 - 17:00	56.58	51.18	54.44	48.06	54.62	0	0	0	0	57.24	52.85	53.77
17:01 - 18:00	53.57	48.46	51.55	45.5	51.71	0	0	0	0	54.2	50.04	50.91
18:01 - 19:00	34.31	31.03	33.01	29.14	33.12	123.9	127.64	137.69	113.51	34.71	32.05	32.61
19:01 - 20:00	16.25	14.7	15.64	13.8	15.69	58.69	60.46	65.22	53.77	16.44	15.18	15.44
20:01 - 21:00	13.84	12.52	13.32	11.76	13.36	49.99	51.5	55.56	45.8	14.01	12.93	13.16
21:01 - 22:00	11.44	10.34	11	9.71	11.04	165	165	165	165	11.57	10.68	10.87
22:01 - 23:00	10.23	9.26	9.85	8.69	9.88	165	165	165	165	10.35	9.56	9.72
23:01 - 24:00	0	0	0	0	0	165	165	165	165	0	0	0

Alternative 3

designing the system

- 12-hour discharge
  - Regulated Energy Cost $37,000
- 6-hour discharge
  - Regulated Energy Cost $33,000

246,000 gal Cost Analysis

Month	J	F	M	A	M	J	J	A	S	O	N	D
Max Demand	50.38	45.57	48.48	42.79	48.64	225.99	225.99	225.99	225.99	50.97	47.06	47.88
Demand Charge	0.5	0.5	0.5	0.5	0.5	9.17	9.17	9.17	9.17	0.5	0.5	0.5
$/month	25.19	22.79	24.24	21.4	24.32	2072.33	2072.33	2072.33	2072.33	25.48	23.53	23.94
$/day	31.44	28.43	30.25	26.7	30.35	174.43	174.43	174.43	174.43	31.8	29.36	29.87
Days	31	28	31	30	31	30	31	31	30	31	30	31
Consumption Cost	974.49	796.2	937.7	801.1	940.7	5232.78	5407.2	5407.2	5232.78	985.8	880.8	926.1
Total Cost	**37003.2**											

153,000 gal Cost Analysis

Month	J	F	M	A	M	J	J	A	S	O	N	D
Max Demand	50.38	45.57	48.48	42.79	48.64	158.28	163.06	175.91	145.01	50.97	47.06	47.88
Demand Charge	0.5	0.5	0.5	0.5	0.5	9.17	9.17	9.17	9.17	0.5	0.5	0.5
$/month	25.19	22.79	24.24	21.4	24.32	1451.46	1495.24	1613.06	1329.78	25.48	23.53	23.94
$/day	31.44	28.43	30.25	26.7	30.35	159.17	160.75	165.02	154.76	31.8	29.36	29.87
Days	31	28	31	30	31	30	31	31	30	31	30	31
Consumption Cost	974.49	796.2	937.7	801.1	940.7	4775.04	4983.37	5115.68	4642.82	985.8	880.8	926.1
Total Cost	**32,840.19**											

designing the system

- Simple Payback
- Hoover Dam Power Up
- Coal must be used to produce electricity
- CO^2 credits could be received

$$\text{Payback (years)} = \frac{\text{Additional First Cost}}{\text{Annual Energy Savings}}$$

Simple Payback Calculation

	Alternative 1	Alternative 2
Additional First Cost	346,625	430,050
Additional Maintenance Cost	6,000	6,000
Annual Savings	19,700	17,185
Payback Period	17.60	25.02

Alternative 1: 870,000 pounds less

Alternative 2: 655,000 pounds less

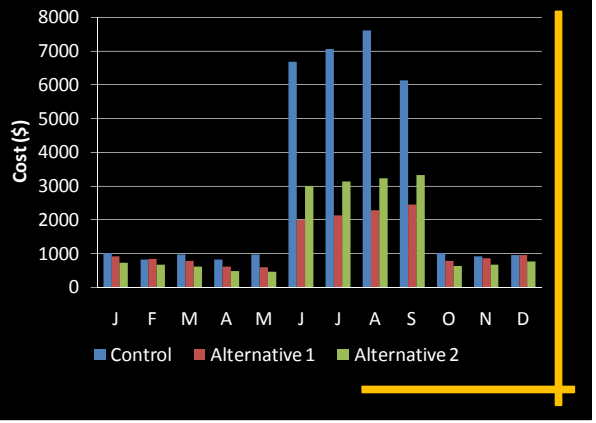
CO^2 Emissions (pounds)

Component			First Cost	Additional First Cost	Annual Maintanence
Control	Chiller	Carrier 19XR	63,000	-	4,000
	Chiller	Carrier 19XR	63,000		4,000
Alternative 1	Absorption Chiller	Carrier 16LJ	103,000	346,625	6,000
	Absorption Chiller	Carrier 16LJ	103,000		6,000
	Boiler	RBI Futera XLF	52,000		500
	Boiler	RBI Futera XLF	52,000		500
	Solar Absorbers (425)		225,625		1,000
	Additional Pumps	B&G	4,000		--
Alternative 2	Absorption Chiller	Carrier 16LJ	103,000	430,050	6,000
	Absorption Chiller	Carrier 16LJ	103,000		6,000
	Boiler	RBI Futera XLF	52,000		500
	Boiler	RBI Futera XLF	52,000		500
	Solar Absorbers (290)		187,050		1,000
	900 ton Storage Tank		82,000		--
	Additional Pumps	B&G	7,000		--
Alternative 3a	Chiller	Carrier 19XR	63,000	301,000	4,000
	Chiller	Carrier 19XR	63,000		4,000
	2,900 ton Storage Tank		295,000		--
	Additional Pumps	B&G	6,000		--
Alternative 3b	Chiller	Carrier 19XR	63,000	246,000	4,000
	Chiller	Carrier 19XR	63,000		4,000
	1,650 ton Storage Tank		240,000		--
	Additional Pumps	B&G	6,000		--

Innovative and Energy Efficiency

payback analysis

- The existing system achieved its design objectives and achieved LEED Gold
- Alternative 1 - $15,000 for absorbers, 7.6 year payback
- Alternative 2 – $17,000 for absorbers, 7.25 year payback chilled water storage
- Alternative 3 – Solar water storage



Roof System

depth summary

- Existing Roof Structure
  - Non-composite (2C 22)
  - 5" depth
  - 7 ft. spans
  - 98 psf (*Vulcraft*)
  - 7'1" max clearspan

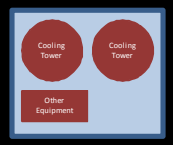
Roof Loads	
Description	Weight (psf)
Mech./Elec./Plumbing	10
Roof Mat	20
Slab/Deck (2C22)	50
Miscellaneous	5
Beams/Joists	10
Total	95

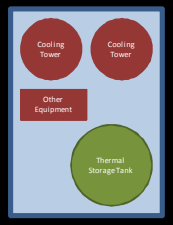
- Solar absorbers: 12.5 psf
- Reduce Joist Spacing
  - 6'6": 113 psf
  - Use 2C 22 at 6' spacing
- Increase Deck Strength
  - 2C 20
  - 127 psf
  - 8'6" max clearspan

Mechanical Yard

structural breadth

- Thermal Storage Tanks
- Calculation shows an extra 20-30 ft. needed





Cost Analysis						
	Component		Material	Labor	Equipment	Total
20 ft. Extension	Strip Footer	12" x 12"	259.26	26.31	0.86	286.43
	Slab	6"	1111.11	159.44	5.00	1275.56
	Wire Fabric	6x6	195.00	147.00	0.00	342.00
	CMU Wall	12" x 10ft.	2169.60	3360.00	0.00	5529.60
	Formwork		22.40	135.10	0.00	157.50
	Total Cost					7591.09
30 ft. Extension	Strip Footer	12" x 12"	333.33	33.83	1.10	368.27
	Slab	6"	1666.67	239.17	7.50	1913.33
	Wire Fabric	6x6	292.50	220.50	0.00	513.00
	CMU Wall	12" x 10ft.	3254.40	5040.00	0.00	8294.40
	Formwork		28.80	173.70	0.00	202.50
	Total Cost					11291.50

Days of Work		
	20 ft. Extension	30 ft. Extension
Strip Footer	0.05	0.06
Formwork	0.13	0.15
Wire Fabric	0.21	0.31
Slab	0.19	0.28
Subtotal	1	1
CMU Wall	2.4	3.6
Total	3.5	5

Do, or not to do?

construction breadth

- ❖Control — lowest initial cost
- ❖Alternative 1 — most energy savings; heaviest roof load; $19,700 cost savings
- ❖Alternative 2 — longer payback; larger mechanical yard

Innovation and Energy Efficiency

"Alternative 1 would not only achieve these goals, but exceed them."

conclusions

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