Future References

MEP infrastructures in the CUP are intended to serve the entire City Hospital campus. The alternate design must perform well for P 1&2, and the completed campus. Since P 1&2 information are the only information available at the moment for City Hospital campus development, it is chosen as basis of analysis. To ensure accuracy of the Trace model, steam and electrical demand from P 1&2 are compared along with steam and electrical demand of similar spaces.

Name	Whitehead Biomedical Research Center	Fred Hutchinson Cancer research Center	Louis Stoke Laboratories, NIH	Research Laboratories University of California	City Hospital Campus Development
Location	Atlanta, GA	Seattle, WA	Bethesda, MD	CA	S.E. PA
Elec. Intensity (kWh/ft^2-yr)	63.3	77.0	67.5	79	56.8
Steam Intensity ($kBtu/sf^2$-yr)	210	-	-	559	372

City Hospital's electricity consumption intensity is on the lower range contributed by City Hospital's chiller plant configuration which the steam turbine chiller(s) give flexibility to the plant as well as lowering its electricity consumption. Overall, the Trace model of City Hospital P 1&2 is within the range of electric and steam intensity of spaces with similar functions. Electricity and steam consumption and demand are compiled and extrapolated to mimic the state of City Hospital campus upon completion.

Basis for Extrapolation			
Peak Electric Intensity		11	W/ft^2
Base Electric Intensity		3	W/ft^2
Peak Steam Intensity		75	$btuh/ft^2$
	Existing Design	Alternate Design	
Elec. Cons. Intensity		57	kWh/ft^2-yr
NG Cons. Intensity	3.0	3.53 - 3.97	$therm/ft^2$-yr
Cost of elec./ft^2	6.27	2.36 - 4.10	$/$ft^2$
Cost of Natural Gas /ft^2	4.08	5.08 - 5.40	$/$ft^2$
CO_2 emission	17.9	3.2 - 7.2	ton/ft^2-yr
No_x emission	15.0	2.7 - 6.1	lbm/ft^2-yr
SO_2 emission	0.7	0.1 - 0.4	lbm/ft^2-yr

City Hospital P1 was completed in March, 2008. However, though completion dates of future constructions remained unknown. Since laboratory and office spaces are the dominant load and energy consumer, they are the prime focus of the analysis. Therefore, three (3) artificial construction milestones are created to evaluate three equipment staging scenarios, and approximately one (1) million square feet of support service spaces, such as mechanical room, loading dock, and parking space are excluded.

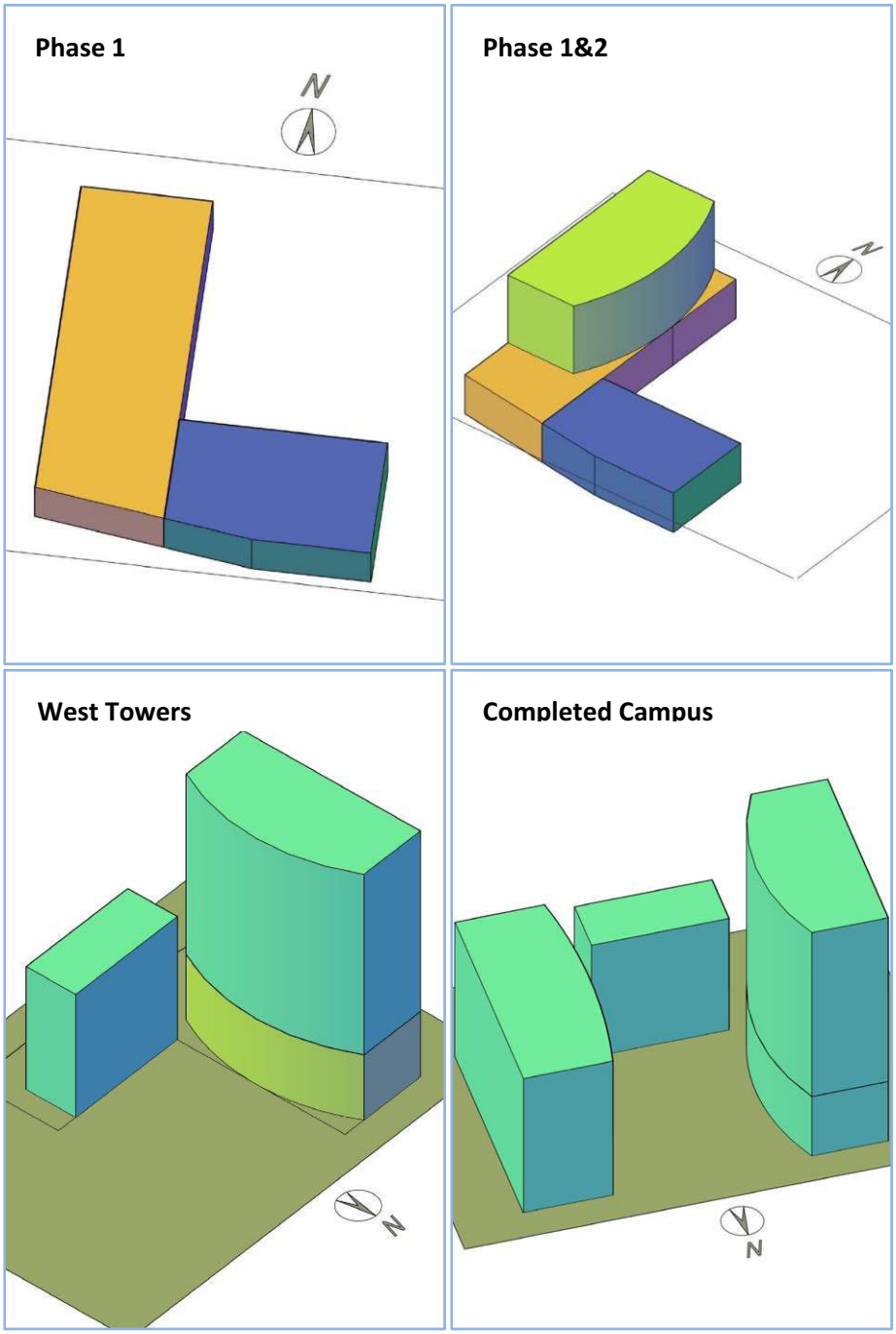

Figure 14: Campus Development Conceptual

Steam and Electricity Demand			
Construction Milestones	Phase 1&2	West Tower	Completed Campus
Square Footage (ft^2)	420,000	1,150,000	2,000,000
Peak Steam Demand (MMBtu/hr)	31.4	85.9	149.4
Natural Gas Consumption (million therm/yr)	1.25	3.42	5.95
Peak Elec. Demand (kW)	4,805	13,157	22,881
Base Elec. Demand (kW)	1,345	3,684	6,407
Electricity Consumption (MWh/yr)	28,647	78,439	136,415

Mechanical Equipment Staging

Bases on the 'Steam and Electricity Demand Table', the existing mechanical system would need two (2), four (4), and six (6) 800 bhp, 32 MMBtuh for construction milestone Phase 1&2, West Tower, and the Completed Campus respectively due to "N+1" design practice for laboratory spaces such as City Hospital.

Equipment Staging							
	Scenario 1				Scenario 2		
Construction Milestones	Phase 1&2	West Tower	Completed Campus		Phase 1&2	West Tower	Completed Campus
1.2 MW Generator	1	2	2				
3.5 MW Generator			1			1	2
HRSG	1	2	3			1	2
800 BHP Boiler	1	2	1		1	2	1
2000 BHP Boiler			1				1
Backup 800 BHP Boiler	1	1	2		1	1	2
Total MW	1.2	2.4	5.9		0.0	3.5	7.0
CHP MMBtuh	9.6	19.2	42.1		0.0	22.9	45.8
Boiler MMBtuh	32.3	64.5	114.7		32.3	64.5	114.7
Available MMBtuh	41.9	83.7	156.8		32.3	87.4	160.5
Backup Boiler MMBtuh	32.3	32.3	64.5		32.3	32.3	64.5
Boiler MMBtuh	64.5	96.8	179.3		64.5	96.8	179.3
Total MMBtuh	74.1	116.0	378.2		64.5	119.7	385.6
Number of Boilers	2	3	4		2	3	4
Number of Equipments	4	7	10		2	5	8

From the 'Equipment Staging of Alternate Design', Scenario 1 would save the most energy. It reduce electricity demand and cost early in the early phase of campus development, and the combination of smaller boilers offers maximum amount of time of high efficiency operation. However, Scenario 3 equipment staging is recommended.

Equipment staging Scenario 2 uses the less number of equipments of the two (2) equipment staging scenarios which minimized capital cost and "lost rentable space". The boiler room of P1 CUP is designed to accommodate six (6) 800 bhp fire tube steam boilers size equipments. It is intended to locate additional boilers in mechanical space which will be part of the CUP extension when construction for East Tower construction begins. Thus, it is best to group all six (6) fire tube steam boilers together in Phase 1 boiler room, and purchase CHP units of higher capacity (3.5 MW, 22.9 MMBtuh steam) at later phase when additional mechanical spaces are built and the demands are high.

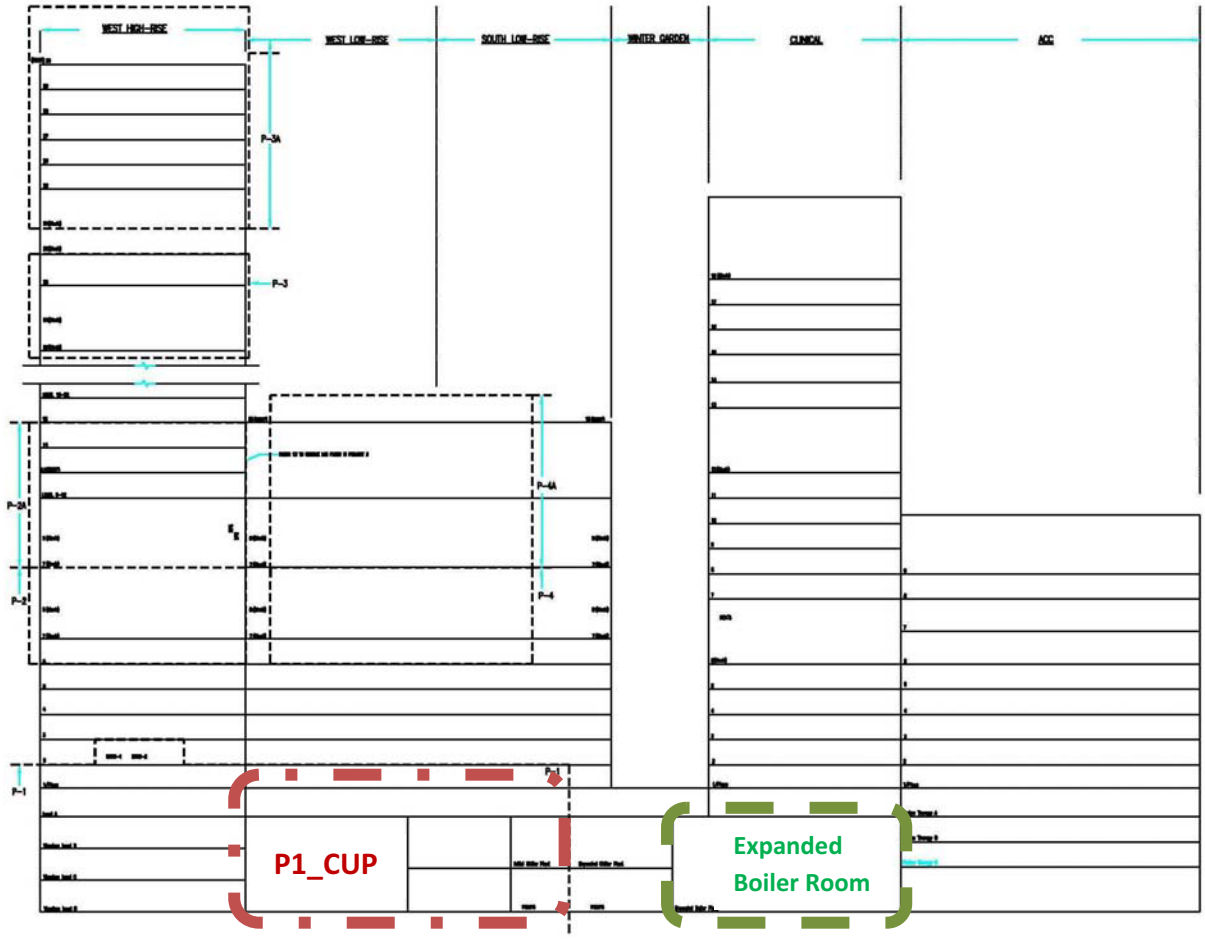

Figure 15: Mechanical Equipment Room Location (For Reference Only)

Alternate Design Saving						
Construction Milestones	West Tower			Completed Campus		
	Exist. Design	Alt. Design	Savings	Exist. Design	Alt. Design	Savings
NG Consumption (therm/yr)	3,420,463	4,057,494		5,948,632	7,935,101	
Electric Cost ($mil/yr)	7.61	4.71		13.23	4.72	
Natural Gas Cost ($mil/yr)	4.65	5.52	2.03	8.09	10.79	5.82
Saving ($mil/yr)			17%			27%
CO_2 emission (1000 ton/yr)	20,570	8,295	12,276	35,775	8,853	26,922
			60%			75%
No_x emission (ton/yr)	8,625	3,486	5,139	15,000	3,724	11,276
			60%			75%
SO_2 emission (ton/yr)	471	216	255	820	210	610
			54%			74%
Car Removed (millions)			**0.54**			**1.18**

As City Hospital campus expands, energy usage escalates linearly with its square footage. When West Tower completes, City hospital would consume 23,872 MWh of electricity and 1.25 million therms of natural gas annually. When City Hospital campus is completed, two (2) million square feet of laboratory and office space, its energy usage would be five (5) time of P 1&2, with 136.5 GWh of electricity and 6.0 million therms of natural gas annually (*Appendix v and vi*).

Small conservation can translate into substantial savings for large development such as City Hospital campus. By incorporating a CHP technology, City Hospital would save $5.82 millions in energy annually when the campus is completed. Likewise, it will have a significant effect on the environment. EPA estimated that an average passenger car emits 11,450 pound of carbon dioxide per year. By generating electricity on-site, it reduced 26.9 million tons of carbon dioxide annually, an equivalent of removing 1.2 million passenger cars off the road. City of Philadelphia only has a population of 1.5 million in 2005.