



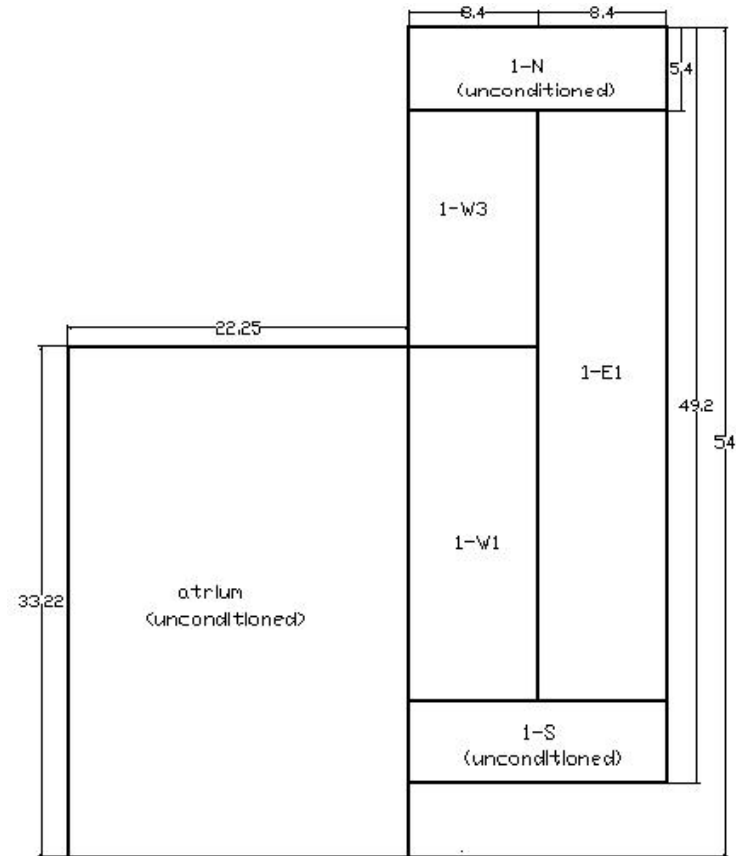
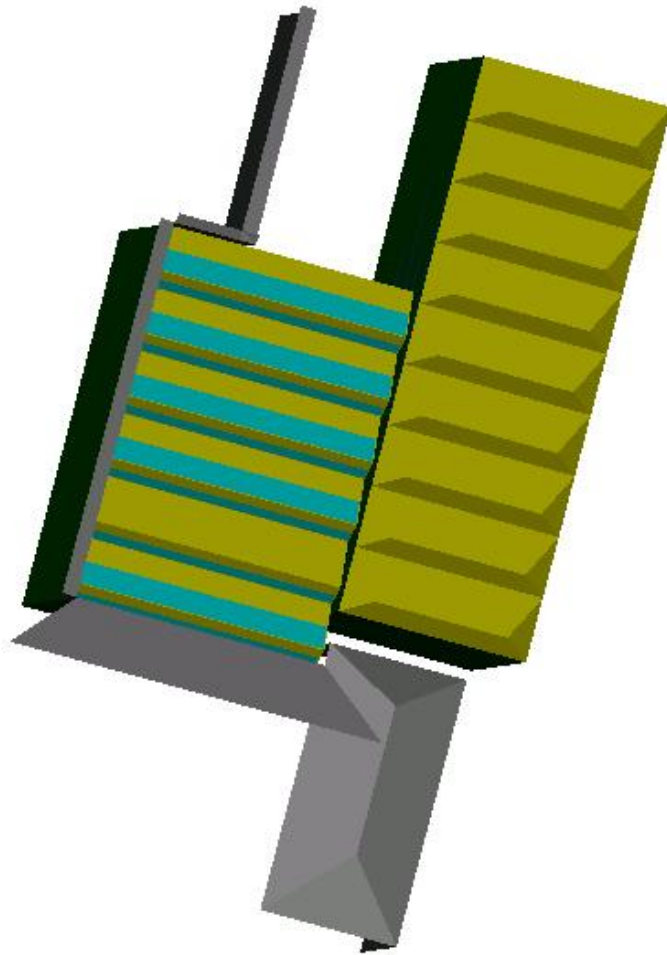
ENERGY PERFORMANCE ANALYSIS FOR BAPP

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CONTENTS

- General simulation specifications
- Energy, operating cost, and pollution analysis for BAPP with typical office equipment load (8.9 W/m²)
- Energy, operating cost, and pollution analysis for BAPP with high office equipment load (ETC 50 W/m² and shop 70 W/m²)
- Next steps

HVAC ZONING



ENERGY RESULTS - ASHRAE CASE

Unit: kWh/m²-yr

Lighting Electricity	Office Equipment Electricity	HVAC Electricity	Total Electricity	Natural Gas	Site Energy	Primary Energy
38.1	28.5	36.7	103.3	18.9	122.2	381.4

Building enclosure is decided based on ASHRAE Standard 90.1-1999

(roof R=3.58 m²-K/W, above grade wall R=2.89 m²-K/W, window U= 3.15 W/m²-K, SHGC =0.35, visible transmittance T_{vis}=0.18)

Electrical lighting 15W/m²

Typical office equipment load 8.9W/m² (source: Paul Komor, *Space Cooling Demands From Office Plug Loads*, ASHRAE Journal, Dec. 1997)

ASCENDING STRATEGIES

Unit: kWh/m²-yr

	Lighting Electricity	HVAC Electricity	Total Electricity	Natural Gas	Site Energy	Primary Energy
ASHRAE	38.1	36.7	103.3	18.9	122.2	381.4
Ascending Strategies	7.8	15.2	51.5	44.5	96	225.2

High performance building envelope

(roof R=7.06 m²-K/W, above grade wall R=2.89 m²-K/W, window U= 1.22 W/m²-K, SHGC =0.31, visible transmittance T_{vis}=0.45)

Daylighting based dimming (setpoint 500 lux)

Tighter enclosure and thus less infiltration (0.1ACH, source: Sheila Hayter, Paul Torcellini, Ron Judkoff, *Optimizing Building And HVAC Systems*, ASHRAE Journal, Dec. 1999)

No security lighting (source: same as above)

Better electrical lighting, 5.4 W/m² (source: Steve Campbell, *Can Intelligent Office Lighting Systems Really Save 80%?* Energy User News, Apr. 2002)

OPERATING STRATEGIES

Unit: kWh/m²-yr

		HVAC Electricity	Total Electricity	Natural Gas	Site Energy	Primary Energy
9.44 L/s-person	ASHRAE	36.7	103.3	18.9	122.2	381.4
	Natural Cooling	9.9	46.2	45.5	91.7	207.6
	Fan-assist Natural Cooling	11.4	47.7	45.5	93.2	212.9
2.36 L/s-person	Demand Ventilation	10.5	46.8	34.5	81.3	198.7
	Demand Ventilation	10.2	46.5	21.8	68.3	185.0

GROUND SOURCE HEAT PUMP

Unit: kWh/m²-yr

		HVAC Electricity	Total Electricity	Natural Gas	Site Energy	Primary Energy
9.44 L/s-person	ASHRAE (Chiller&Boiler)	36.7	103.3	18.9	122.2	381.4
	Chiller&Boiler	11.6	47.9	31.4	79.3	199.5
	GSHP	19.8	56.1	0	56.1	196.8
2.36 L/s-person	Chiller&Boiler	11.1	47.4	18.6	66.0	184.9
	GSHP	13.5	49.8	0	49.8	174.7

DISTRIBUTED POWER GENERATION

Unit: kWh/yr

	Building Electricity Consumption	Electricity Generation	Electricity from Grid	Electricity to Grid	Thermal from Grid	Thermal to Grid	Natural Gas from Grid
9.44 L/s-person	ASHRAE	904,908	0	904,908	0	0	93,725
	GSHP+PV	278,048	54,411	230,447	6,810	0	0
	GSHP+SOFC	278,048	1,979,760	8	1,701,720	0	4,866,667
	GSHP+PV+SOFC	278,048	2,034,171	0	1,756,123	0	4,866,667
2.36 L/s-person	GSHP+PV	246,958	54,411	205,072	6810	0	0
	GSHP+SOFC	246,958	1,979,760	0	1,727,087	0	4,866,667
	GSHP+PV+SOFC	246,958	2,034,171	0	1,781,498	0	4,866,667

PV on south facing BAPP roof, area 355m², efficiency 12%

SOFC: Natural gas input: 556kW, Electricity output: 226kW, Rejected heat: 150kW

ENERGY CONSUMPTION, OPERATING COST AND POLLUTION

	Site Energy (kWh/m ² -yr)	Primary Energy (kWh/m ² -yr)	Operating Cost (\$)	Carbon Equivalent (kg)
ASHRAE	122.2 (100%)	381.4 (100%)	\$50,945 (100%)	202,480 (100%)
Ascending Strategies	96 (79%)	225.2 (59%)	\$27,841 (55%)	112,503 (56%)
Operating Strategies	79.3 (65%)	199.5 (52%)	\$25,304 (50%)	101,295 (50%)
GSHP	56.1 (46%)	196.8 (51%)	\$35,505* (70%)	106,551 (53%)
GSHP+PV	45.1 (37%)	158.2 (41%)	\$31,140* (61%)	85,700 (42%)
GSHP+PV+SOFC	80.4** (66%)	80.4 (21%)	-\$7,413*** (-15%)	21,270 (11%)
Electric Chiller &Heat Exchanger +PV+SOFC	90.3** (74%)	90.3 (24%)	-\$5,462*** (-11%)	23,889 (12%)

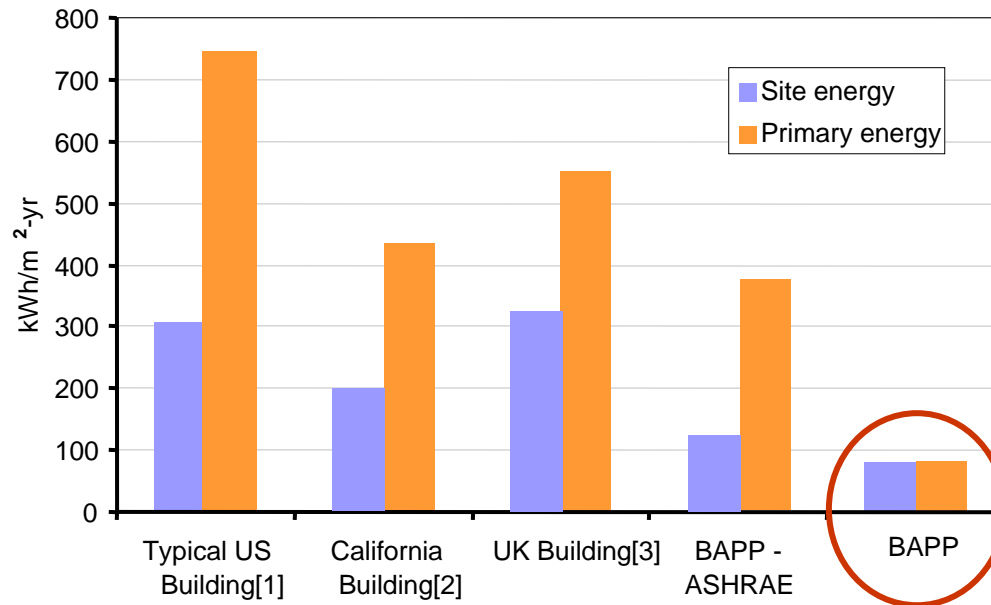
* high demand charge

** natural gas

*** Assume additional electricity and thermal energy are used by the campus. The operating cost for this case does not include the electric demand charge reduction of the campus.

BAPP COMPARED TO OTHER OFFICE BUILDINGS

11% primary energy consumption of typical US office building



* 1995 Commercial Building Energy Consumption Survey, Energy Information Administration

** Pacific Gas and Electric Company, Commercial Building Survey Report, 1999

*** Probe 1999

ENERGY, COST AND POLLUTION SIMULATION RESULTS FOR BAPP*

	Site Energy (kWh/m ² -yr)	Primary Energy (kWh/m ² -yr)	Operating Cost (\$)	Carbon Equivalent (kg)
ASHRAE	247.1 (100%)	837.5 (100%)	\$90,197 (100%)	450,933 (100%)
Ascending Strategies	198.6 (80%)	636.1 (76%)	\$67,973 (75%)	339,377 (75%)
Operating Strategies	165.7 (67%)	540.0 (64%)	\$59,995 (67%)	288,918 (64%)
GSHP	152.6 (62%)	535.4 (64%)	\$63,576 (70%)	290,062 (65%)
GSHP+PV	141.6 (57%)	496.8 (59%)	\$60,252 (67%)	269,211 (60%)
GSHP+PV+SOFC	254.4** (103%)	254.4 (30%)	\$8,188 (9%)	67,301 (15%)
Electric Chiller &Heat Exchanger +PV+SOFC	260.9**(106%)	260.9 (31%)	\$9,408 (10%)	69,020 (15%)

* high office equipment load 115.3 kWh/m²-yr, compared to typical office equipment load 28.5 kWh/m²-yr. ** natural gas

ENERGY PERFORMANCE - EXCLUDING OFFICE EQUIPMENT LOAD*

	Site Energy (kWh/m ² -yr)	Primary Energy (kWh/m ² -yr)	Operating Cost (\$)	Carbon Equivalent (kg)
ASHRAE	247.1	837.5	\$90,197	450,933
ASHRAE Excluding Office Equipment Load	131.8	432.9	\$50,011	231,837
GSHP+PV+SOFC	254.4	254.4	\$8,188	67,301
GSHP+PV+SOFC Excluding Office Equipment Load	47.2	47.2	-\$10,450	12,487

* office equipment load: 115.3 kWh/m²-yr

NEXT STEPS

Energy, cost, and pollution impact from:

- Absorption chiller driven by rejected heat
- Desiccant unit driven by rejected heat
- Radiant panel for cooling and heating
- Enthalpy exchange
- Solar thermal
- Engine generator
- Gas turbine
- Operable window