Use of A Cooling, Heating & Power System in a Supermarket, or

Richard Sweetser
President
EXERGY Partners Corp.

Anatomy of a Research, Test & Verification Project

Richard Sweetser
President
EXERGY Partners Corp.

Lessons Learned

Test Site

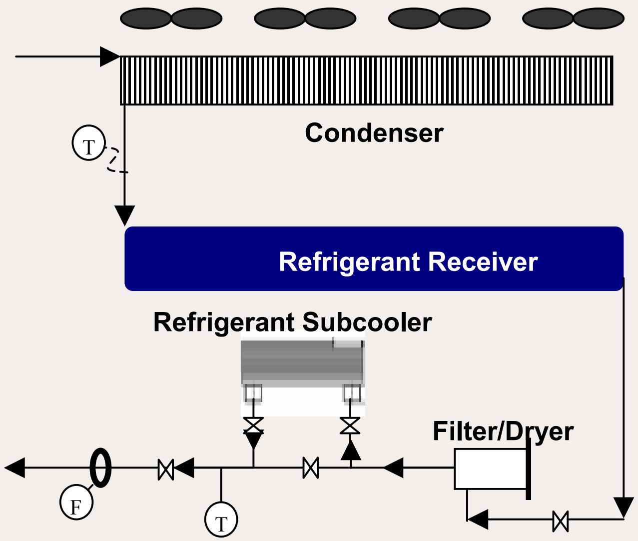
- A 71,000 square foot existing supermarket located in southwestern Texas.
- The store is equipped with one low temperature rack, one split temperature rack, two medium temperature racks and a dual path HVAC system.
- The four refrigeration systems are packaged rooftop units.

Rooftop

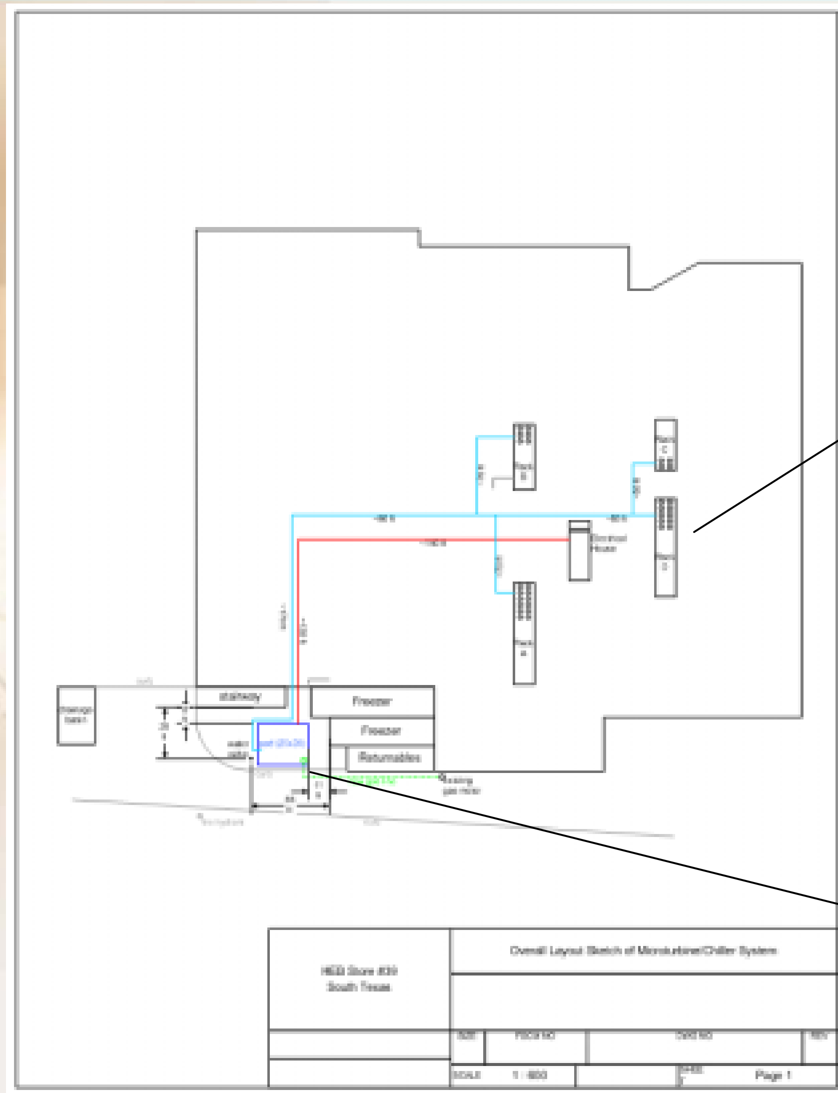
- The basic premise for the test is to supply enough continuous on-site power to provide thermal energy for an absorption chiller to supply liquid refrigerant sub-cooling to the low temperature and medium temperature refrigeration racks.

Condensing Unit

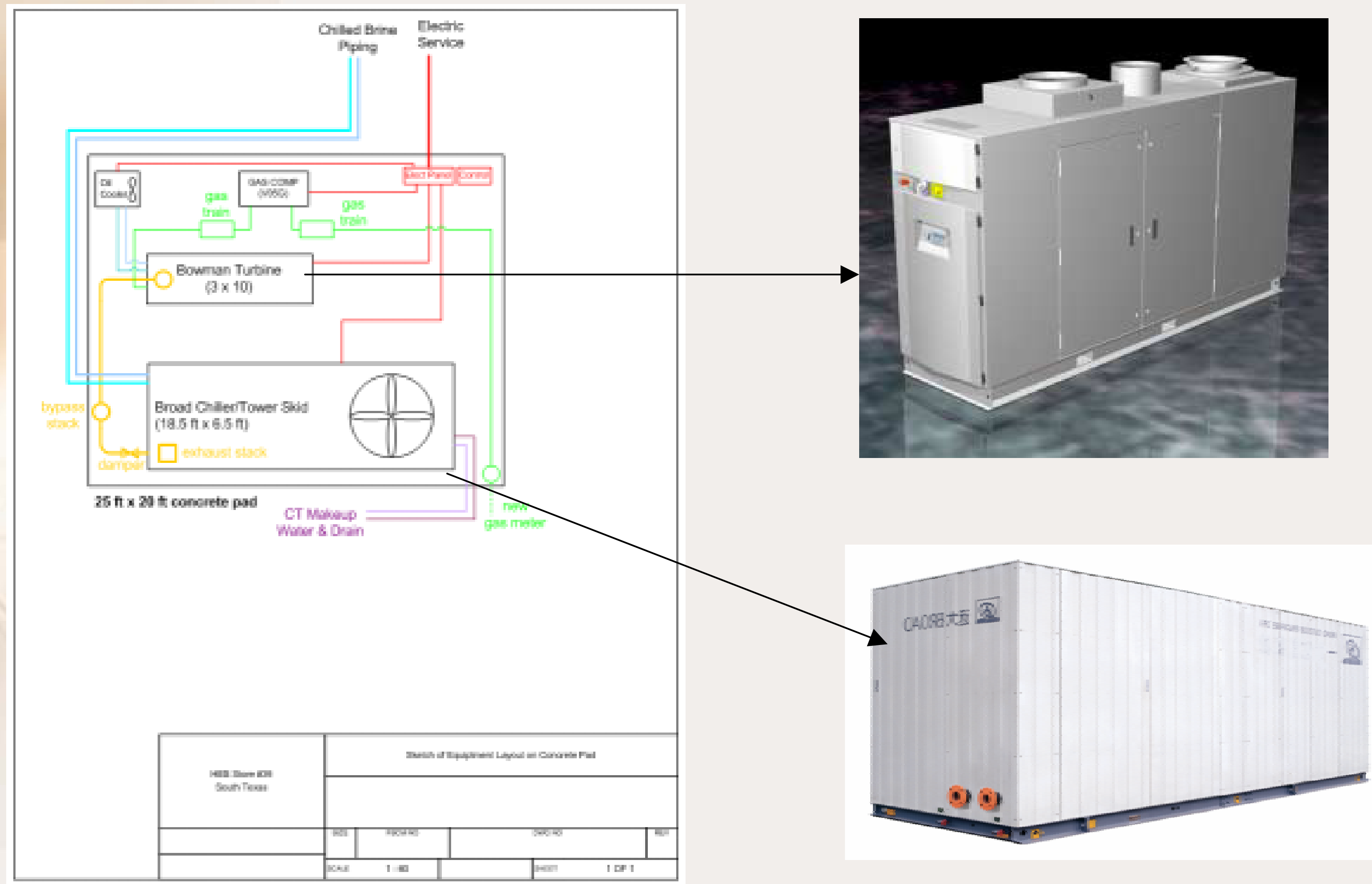
- Calculations, assuming a lithium bromide absorption system, show that subcooling liquid refrigerant to 45°F on each of the four refrigeration condensing units would require a minimum of 15 RT, average of 18 RT and maximum of 31 RT. The essential element is not to take the store grid independent, but to effectively use the thermal energy to provide the liquid refrigerant sub-cooling.



The Test Plan

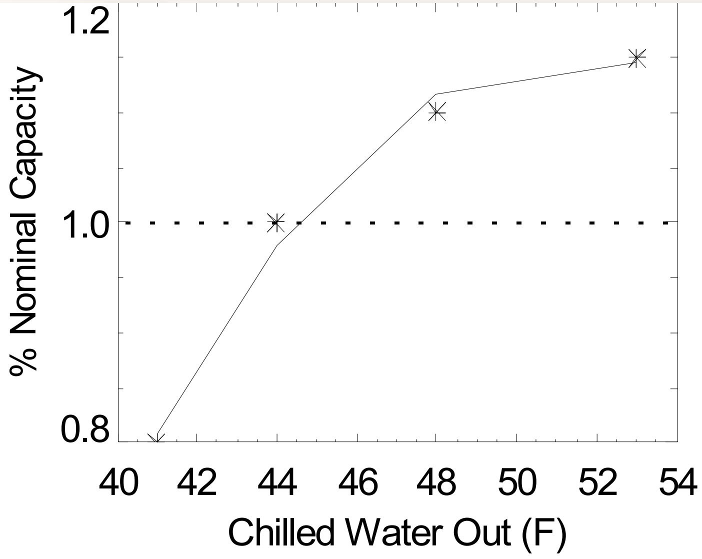


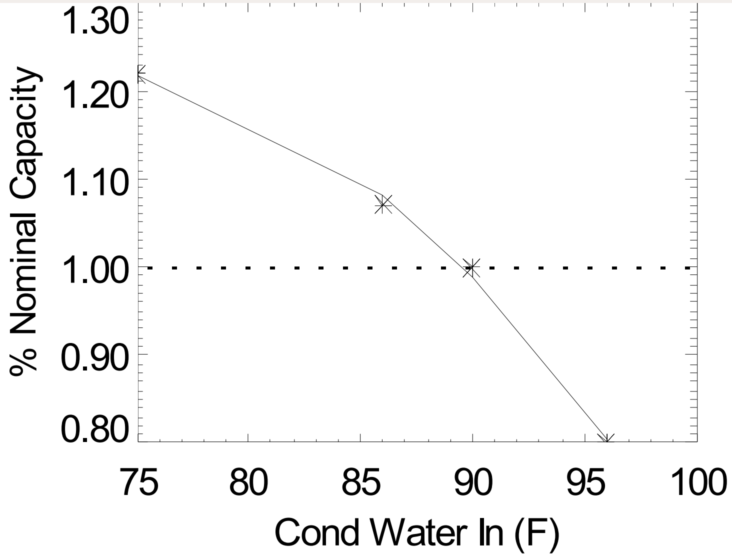
Equipment Layout



Absorption Chiller Performance

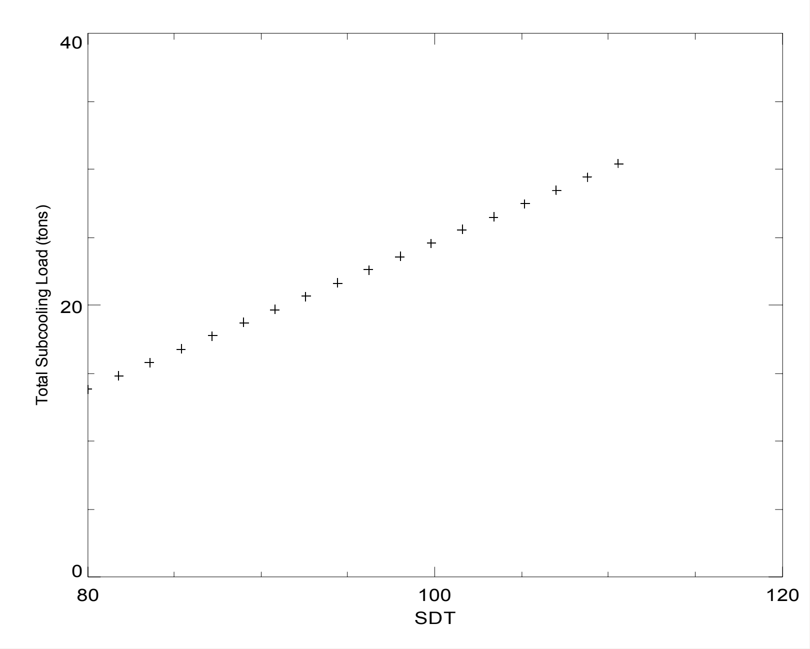
- **The capacity of the lithium bromide/water chiller is assumed to vary with condenser and chilled water temperature according to the graphs below. Net Capacity is assumed to be 20 tons.**
- **The chilled water supply temperature is assumed to be held above 41°F. The condenser water is assumed to be the wet bulb + 9°F, but not less than 75°F.**





Sub-cooling Load

- **The sub-cooling load to maintain the liquid temperature at 45°F is shown below. The liquid temperature entering the sub-cooler is assumed to be 5°F lower than SDT.**
- **In reality the chiller is sized at 20 tons, so the refrigerant will not be cooled to 45°F at all times. SDT is assumed to 12°F greater than ambient, but never to drop below 80°F.**

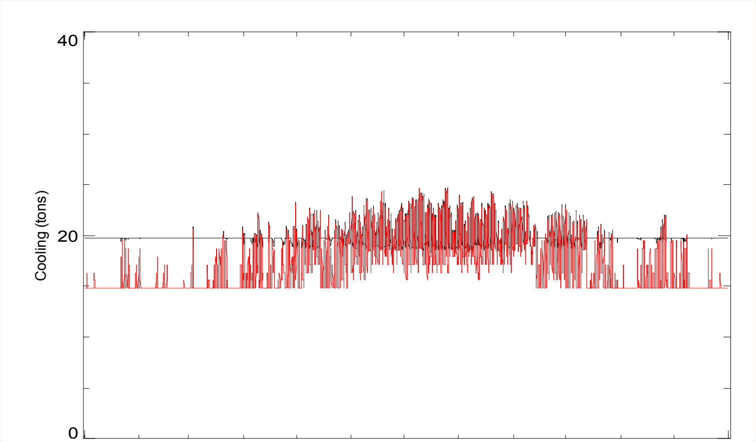


HX Assumptions

- We assume the following performance HX and chiller:
  - *HX effectiveness:* *92% (minimum flow on refrigerant side)*
  - *Chiller capacity:* *20 tons (nominal)*
  - *Chiller delta-T:* *16°F (nominal)*
  - *Chiller flow:* *30 gpm (constant; total for all HX's)*

Chiller Load Calculation

- **Iterative calculations at peak ambient: 98.6°F (SDT = 110.6°F)**
- **Chiller Capacity: 24.7 tons at 49°F brine supply and 68.7°F brine return with 85.7°F condensing temperature and 105.6°F entering, 53.5°F leaving liquid refrigerant.**
- **The chilled water temperature will float down to a minimum of 41°F as ambient temperature lowers. The plot below compares the available chiller capacity to the subcooling loads.**
- **The minimum liquid temperature achieved with the 41°F chilled water temperature is 43.7°F.**
- **The amount of modulation of chiller capacity in this case is modest so the chiller should be able to match the load.**



Anticipated Performance

Nominal Impact of Refrigerant Subcooling with 40¢ gas - 5¢ avg electricity	
152,000	ton-hrs
1.40	avg kW/ton (weighted avg for medium and Low temp racks)
212,800	kWh
0.06	$/kWH
12,768	$ Heat Recovery Benefit

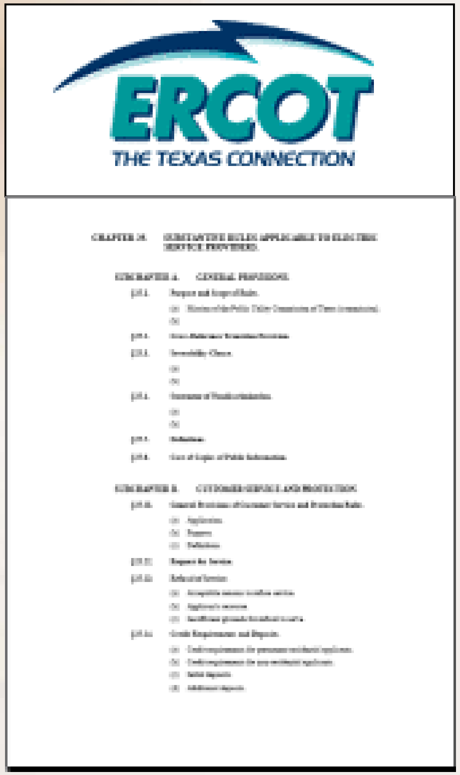
	Bowman	35% Lower cost Bowman	35% Lower cost + 20% > HR Bowman
Nominal Size (kW)	80	80	80
Inlet cooling	Yes	Yes	Yes
Avg Annual Power (kW)	78	78	78
Avg Annual Efficiency (HHV)	26%	26%	26%
Annual Energy Output (kWh)	683,280	683,280	683,280
Avg Gas Consumption (therms/h)	10.4	10.4	10.4
Annual Gas Consumption (therms)	90,854	90,854	90,854
Portion of Heat Recovery Benefit	100%	100%	100%
Gas Cost for Generation	$ 36,342	$ 36,342	$ 36,342
Electric Generation Benefit	$ 34,164	$ 34,164	$ 34,164
Heat Recovery Benefit	$ 12,768	$ 12,768	$ 15,322
Savings	**$ 10,590**	**$ 10,590**	**$ 13,144**
Approximate Capital Cost (generation, chiller, tower + some controls)	$ 200,000	$ 130,000	$ 130,000
Approx Simple Payback	18.9	12.3	9.9

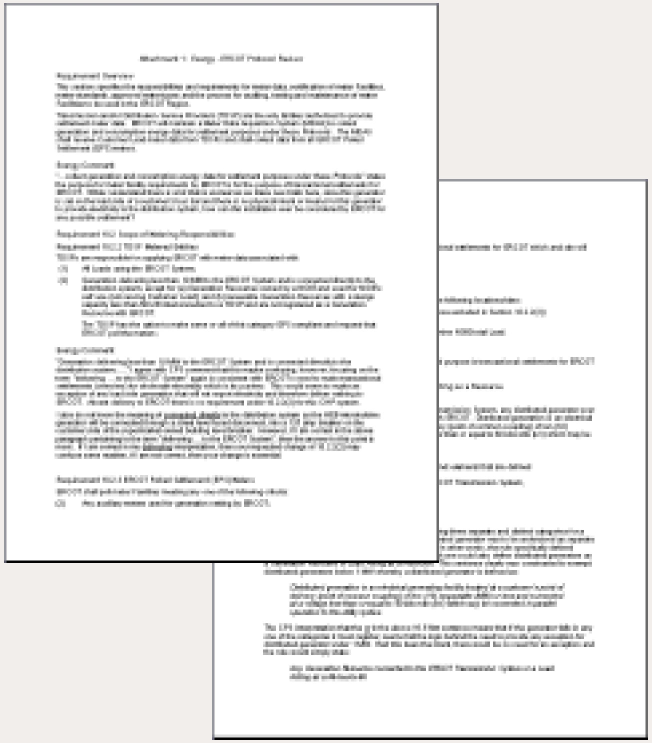
Anticipated Performance

Nominal Impact of Refrigerant Subcooling with 80¢ gas - 12¢ avg electricity	
152,000	ton-hrs
1.40	avg kW/ton (weighted avg for medium and Low temp racks)
212,800	kWh
0.13	$/kWH
27,664	$Heat Recovery Benefit

	Bowman	35% Lower cost Bowman	35% Lower cost + 20% > HR Bowman
Nominal Size (kW)	80	80	80
Inlet cooling	Yes	Yes	Yes
Avg Annual Power (kW)	78	78	78
Avg Annual Efficiency (HHV)	26%	26%	26%
Annual Energy Output (kWh)	683,280	683,280	683,280
Avg Gas Consumption (therms/h)	10.4	10.4	10.4
Annual Gas Consumption (therms)	90,854	90,854	90,854
Portion of Heat Recovery Benefit	100%	100%	100%
Gas Cost for Generation	$ 72,683	$ 72,683	$ 72,683
Electric Generation Benefit	$ 81,994	$ 81,994	$ 81,994
Heat Recovery Benefit	$ 27,664	$ 27,664	$ 33,197
Savings	**$ 36,975**	**$ 36,975**	**$ 42,507**
Approximate Capital Cost (generation, chiller, tower + some controls)	$ 200,000	$ 130,000	$ 130,000
Approx Simple Payback	5.4	3.5	3.1

ISO ERCOT Transaction Meter





TCEQ

East Texas Region:

- *(i) Units installed prior to January 1, 2005 and*
  (a) operating > 300 hours per year - 0.47 lb/MWh;
  (b) operating ≤ 300 hours per year - 1.65 lb/MWh;

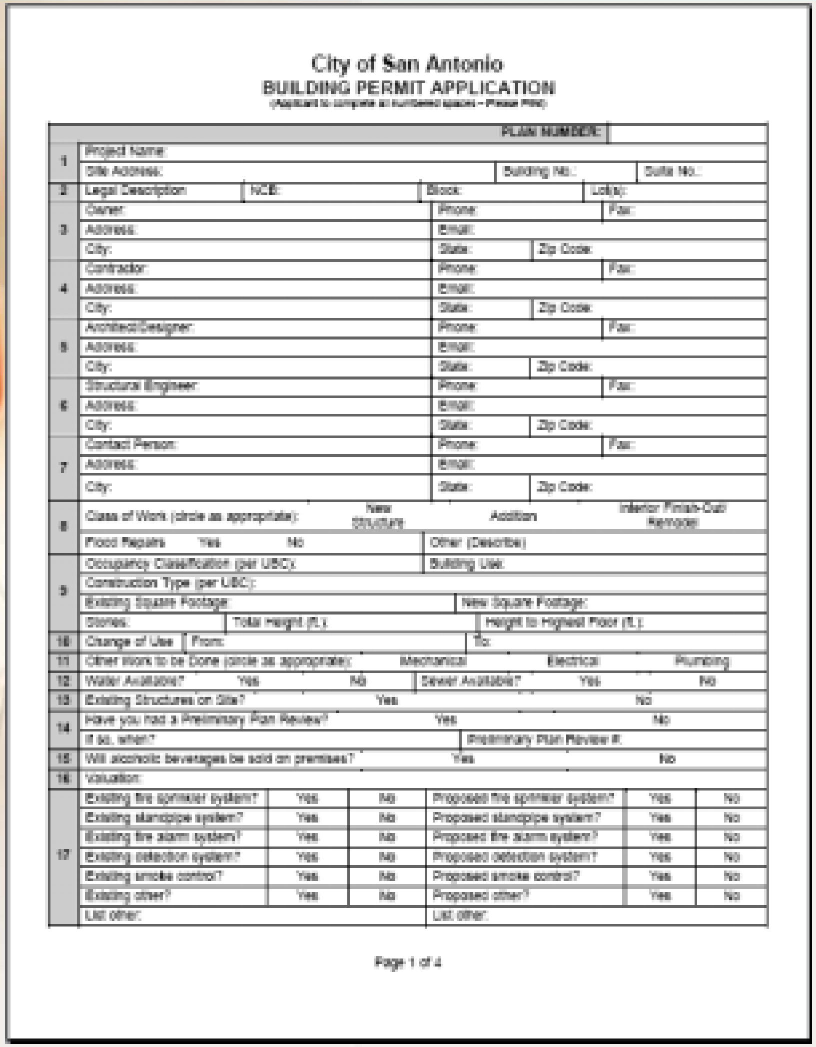
- *(ii) Units installed on or after January 1, 2005 and*
  (a) operating > 300 hours per year - 0.14 lb/MWh;
  (b) operating ≤ 300 hours per year - 0.47 lb/MWh;

TCEQ CHP Emissions Calculations

	Initial Year	Later Years (10% Degraded)	Calculations
	lb / MWh	lb / MWh	
Bowman Microturbine NOx Emissions Rate	0.62	0.682	***[1]***
Microturbine Electricity Production (kWh/yr)	654.3		***[2]***
Average Electric Output (kW)	74.7		
Microturbine NOx Emissions (lb/yr)	405.7	446.2	***[3] = [1] x [2]***
Chilled Water Load (ton-hr/yr)	152,518		***[4]***
Average Chiller Load (tons)	17.4		
Thermal Input to Chiller (MMBtu)	3,050.4		***[5] = [4] / COP***
Equivalent CHP Output (MWh)	1,548.0		***[6] = [2] + [5] / 3.413***
CHP System NOx Emissions Rate (lb / MWh)	**0.262**	**0.288**	***[7] = [3] / [6]***

TCEQ Permit Paperwork

Building Permit



City of San Antonio
BUILDING PERMIT APPLICATION

					PLAN NUMBER:	
1	Project Name:					
	Site Address:			Building No.:	Suite No.:	
2	Legal Description:	NCB:	Block:	Lot(s):		
3	Owner:		Phone:	Fax:		
	Address:		Email:			
	City:		State:	Zip Code:		
4	Contractor:		Phone:	Fax:		
	Address:		Email:			
	City:		State:	Zip Code:		
5	Architect/Designer:		Phone:	Fax:		
	Address:		Email:			
	City:		State:	Zip Code:		
6	Structural Engineer:		Phone:	Fax:		
	Address:		Email:			
	City:		State:	Zip Code:		
7	Contact Person:		Phone:	Fax:		
	Address:		Email:			
	City:		State:	Zip Code:		
8	Class of Work (circle as appropriate):	New Structure	Addition	Interior Finish-Out/ Remodel		
	Flood Repairs Yes No		Other (Describe)			
9	Occupancy Classification (per UBC):		Building Use:			
	Construction Type (per UBC):					
	Existing Square Footage:		New Square Footage:			
	Stories:	Total Height (ft.):	Height to Highest Floor (ft.):			
10	Change of Use	From:	To:			
11	Other Work to be Done (circle as appropriate):	Mechanical	Electrical	Plumbing		
12	Water Available?	Yes	No	Sewer Available?	Yes	No
13	Existing Structures on Site?	Yes	No			
14	Have you had a Preliminary Plan Review?	Yes	No			
	If so, when?		Preliminary Plan Review #:			
15	Will alcoholic beverages be sold on premises?	Yes	No			
16	Valuation:					
17	Existing fire sprinkler system?	Yes	No	Proposed fire sprinkler system?	Yes	No
	Existing standpipe system?	Yes	No	Proposed standpipe system?	Yes	No
	Existing fire alarm system?	Yes	No	Proposed fire alarm system?	Yes	No
	Existing detection system?	Yes	No	Proposed detection system?	Yes	No
	Existing smoke control?	Yes	No	Proposed smoke control?	Yes	No
	Existing other?	Yes	No	Proposed other?	Yes	No
	List other:			List other:		

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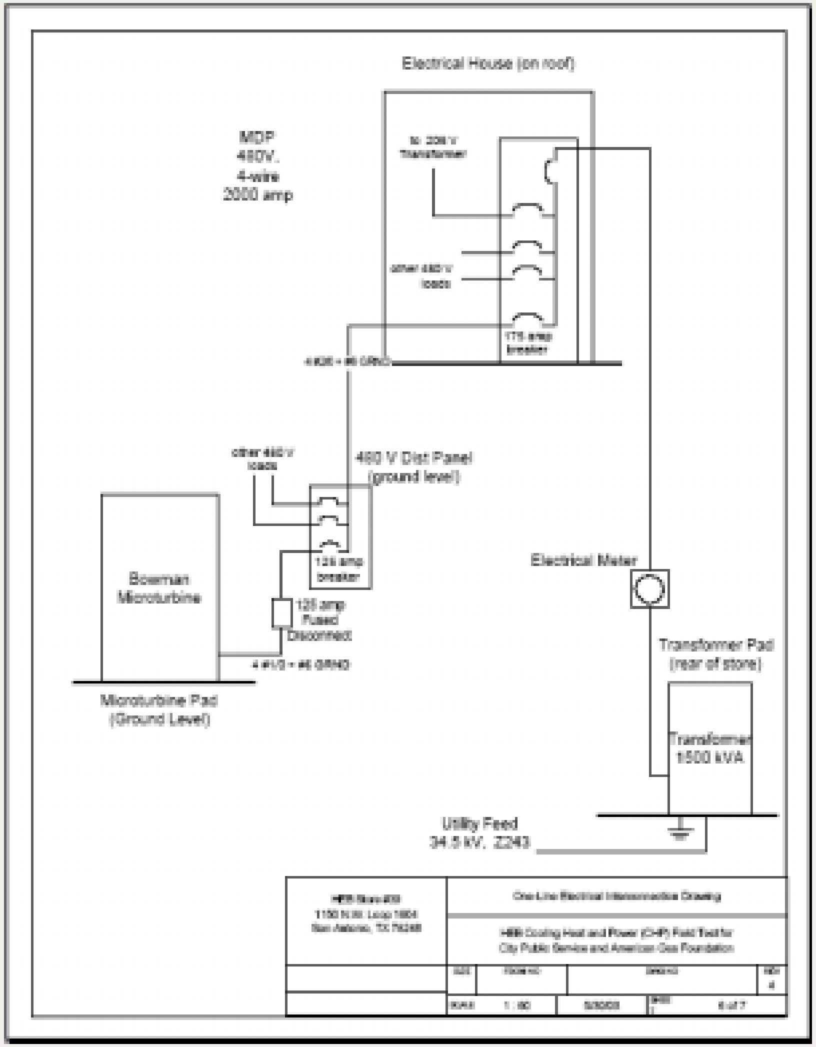
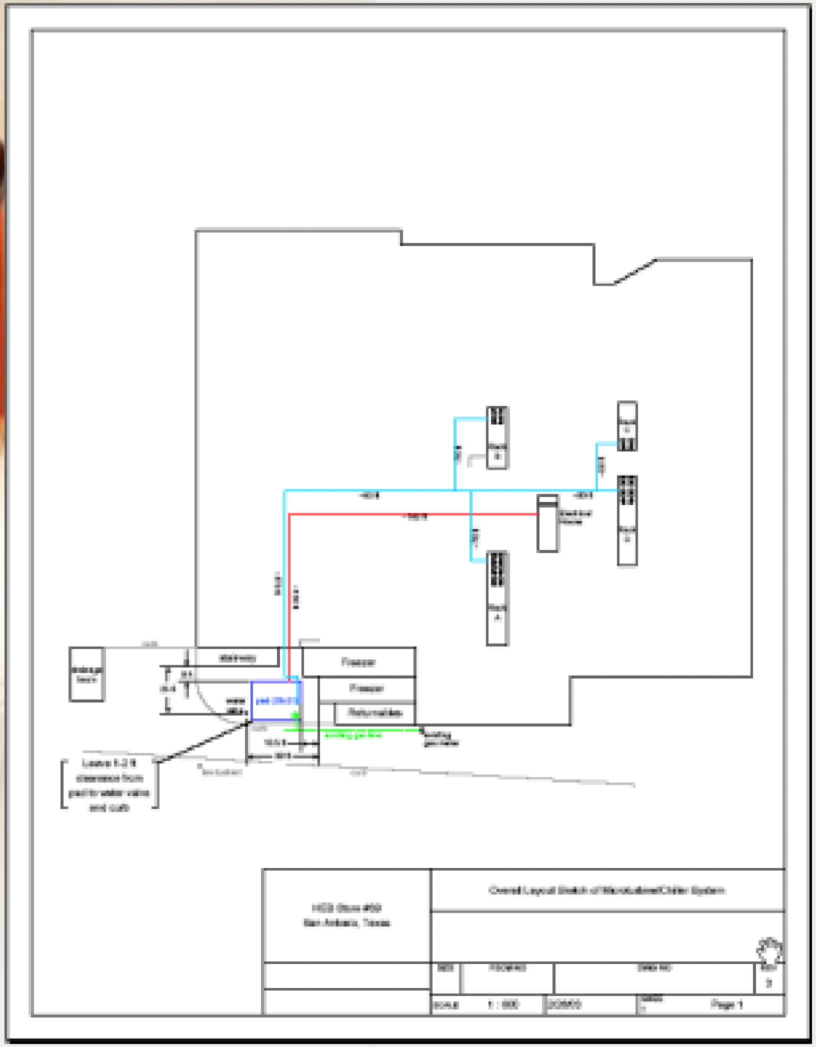
APPLICATION

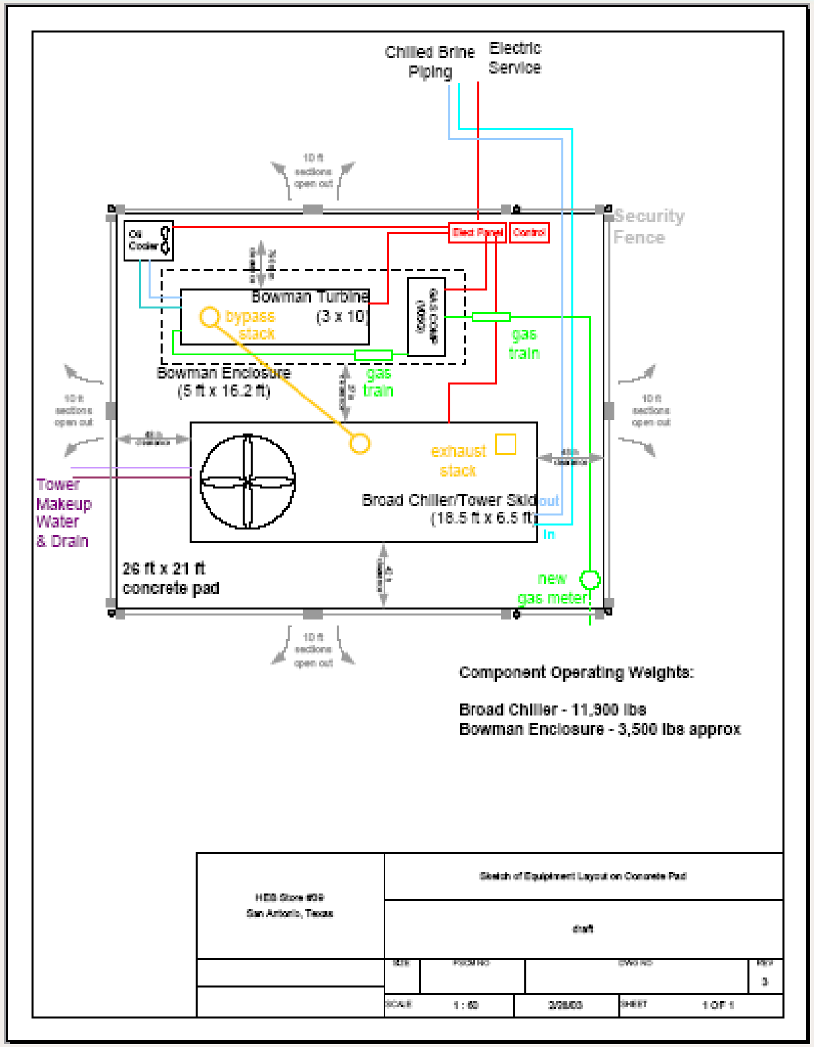


ELECTRICAL ONE LINE

Building Permit

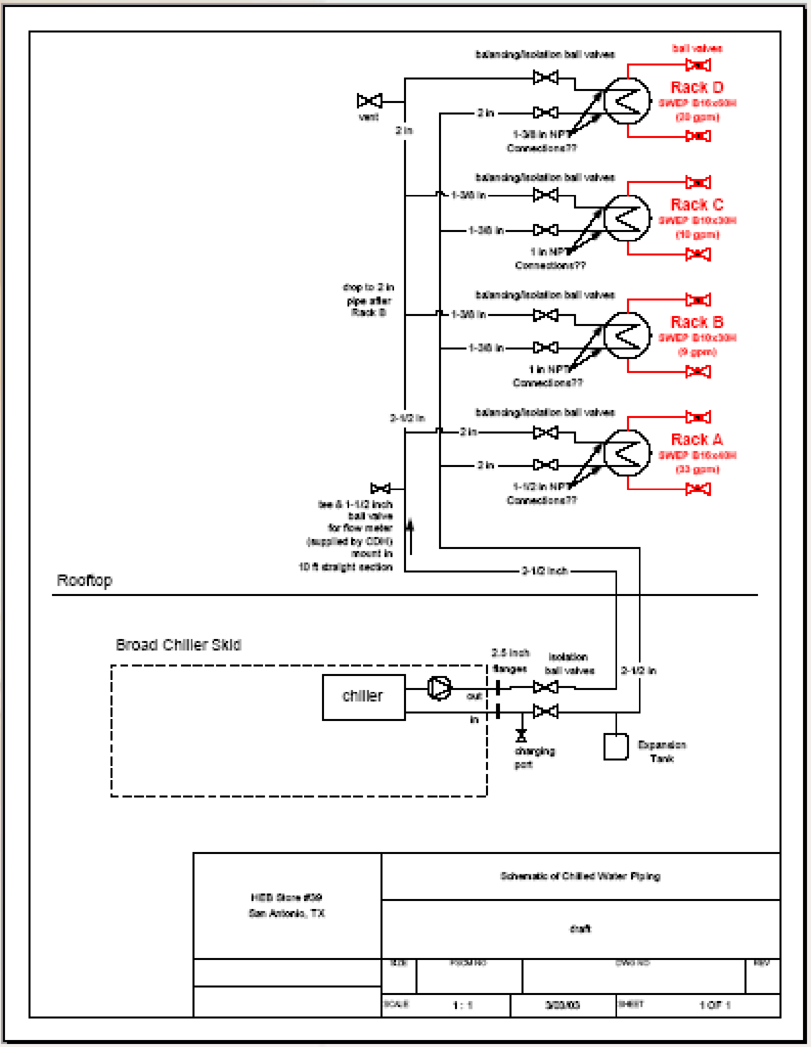


GENERAL PROJECT LAYOUT

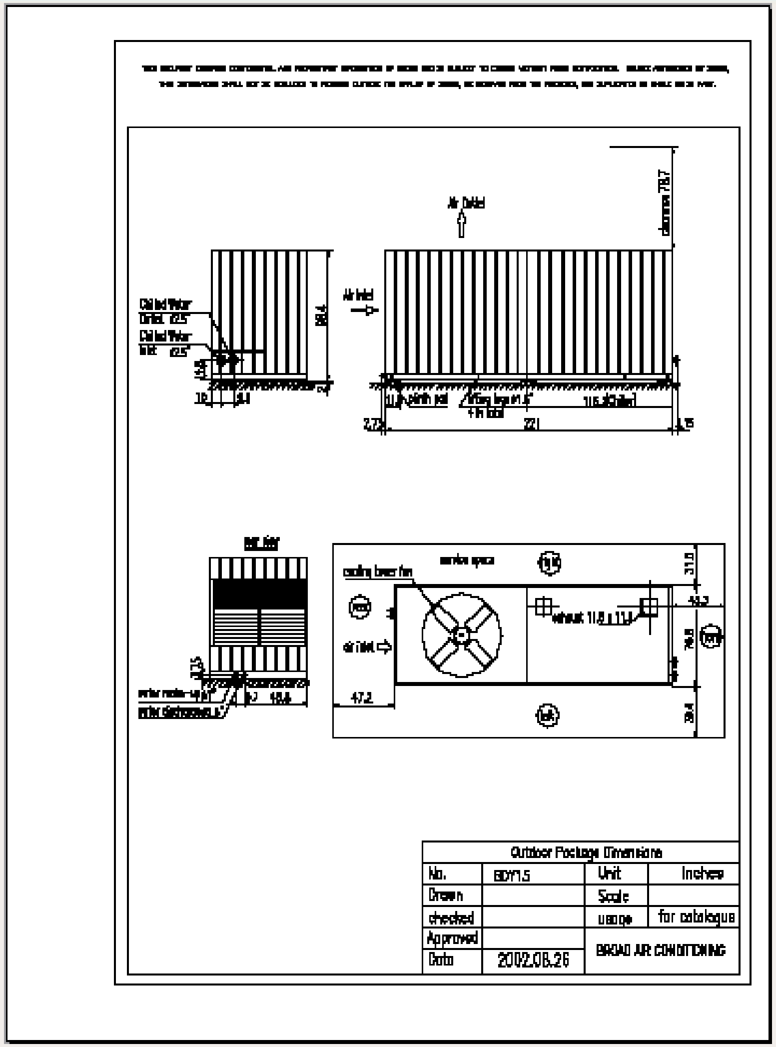


EQUIPMENT PAD LAYOUT

Building Permit

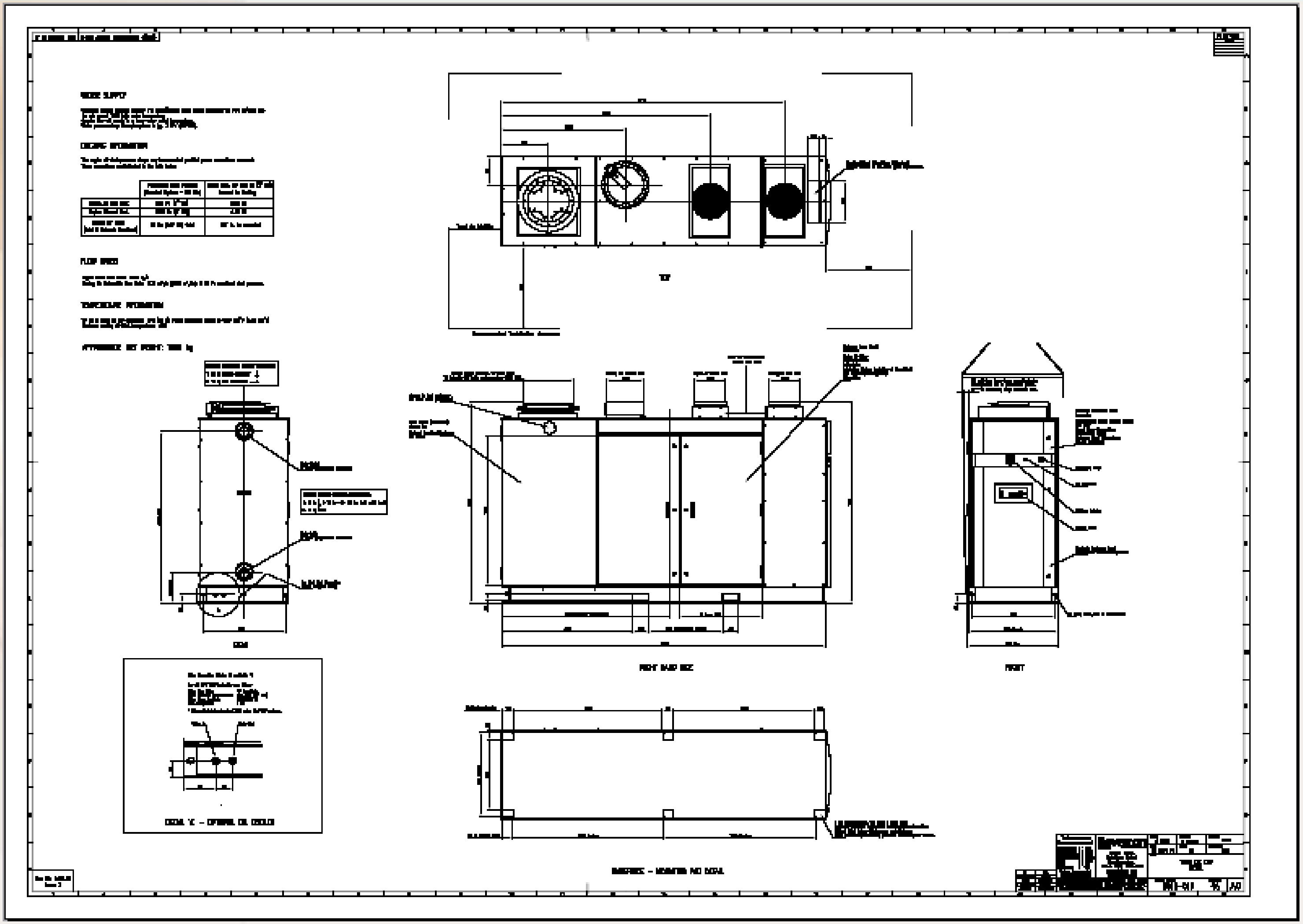


CHILLED WATER PIPING



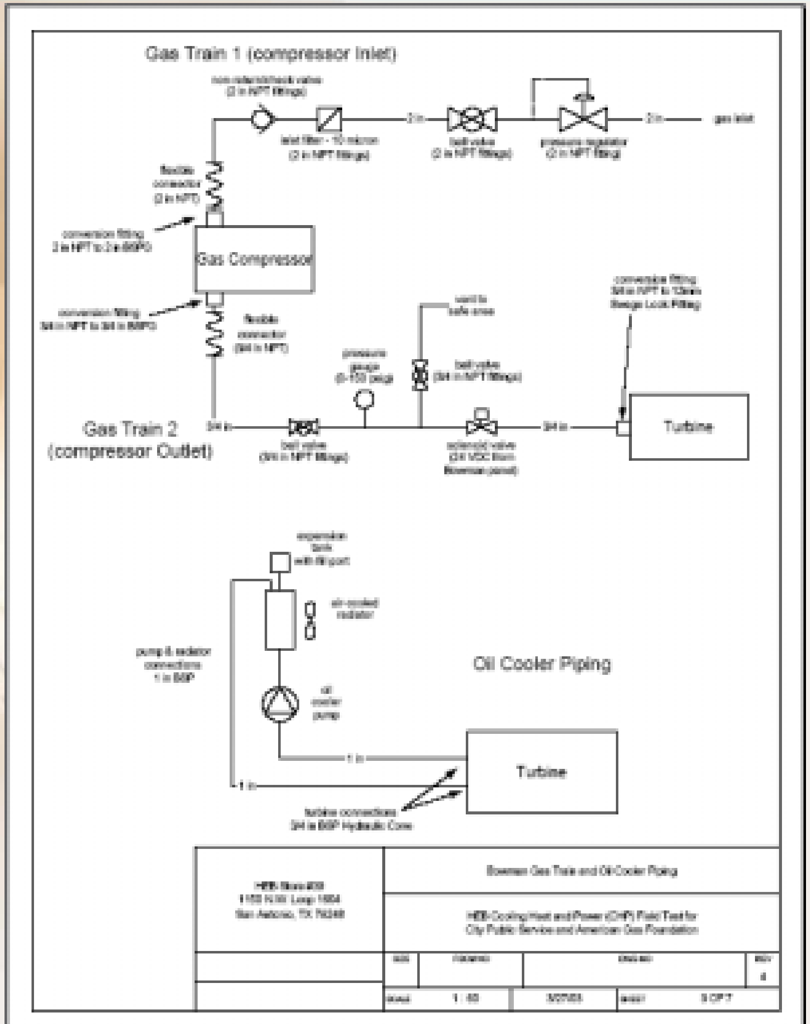
CHILLER MODULE

Building Permit

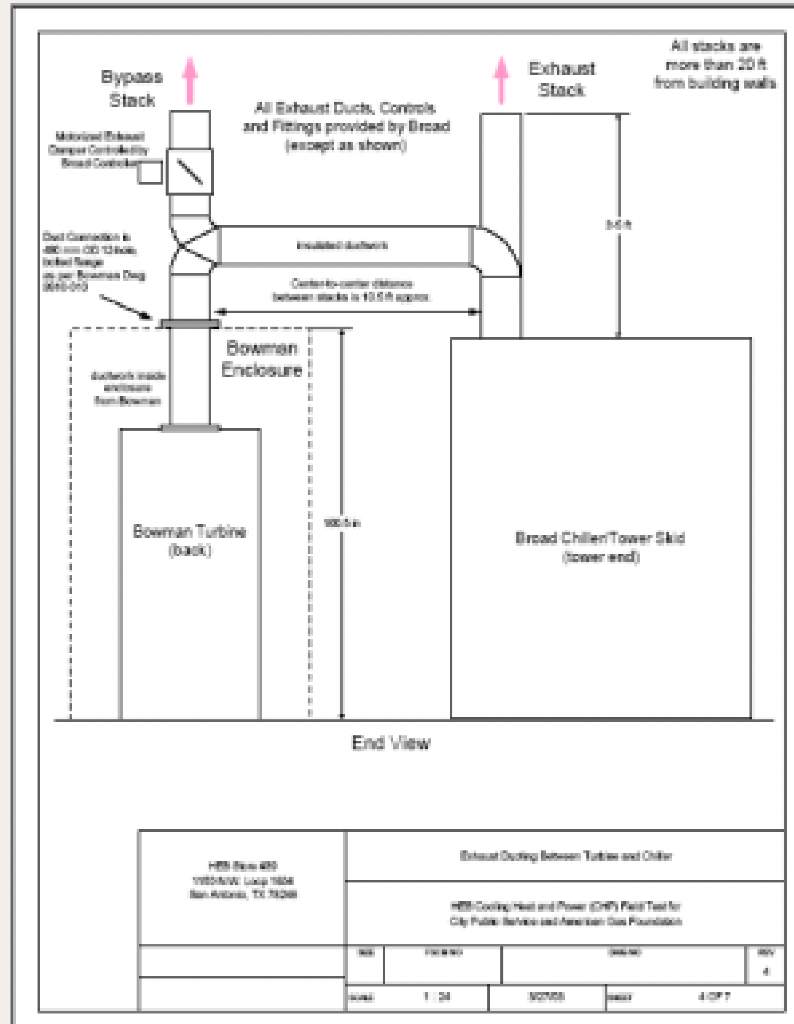


MICROTURBINE

Building Permit



GAS TRAIN & OIL PIPING

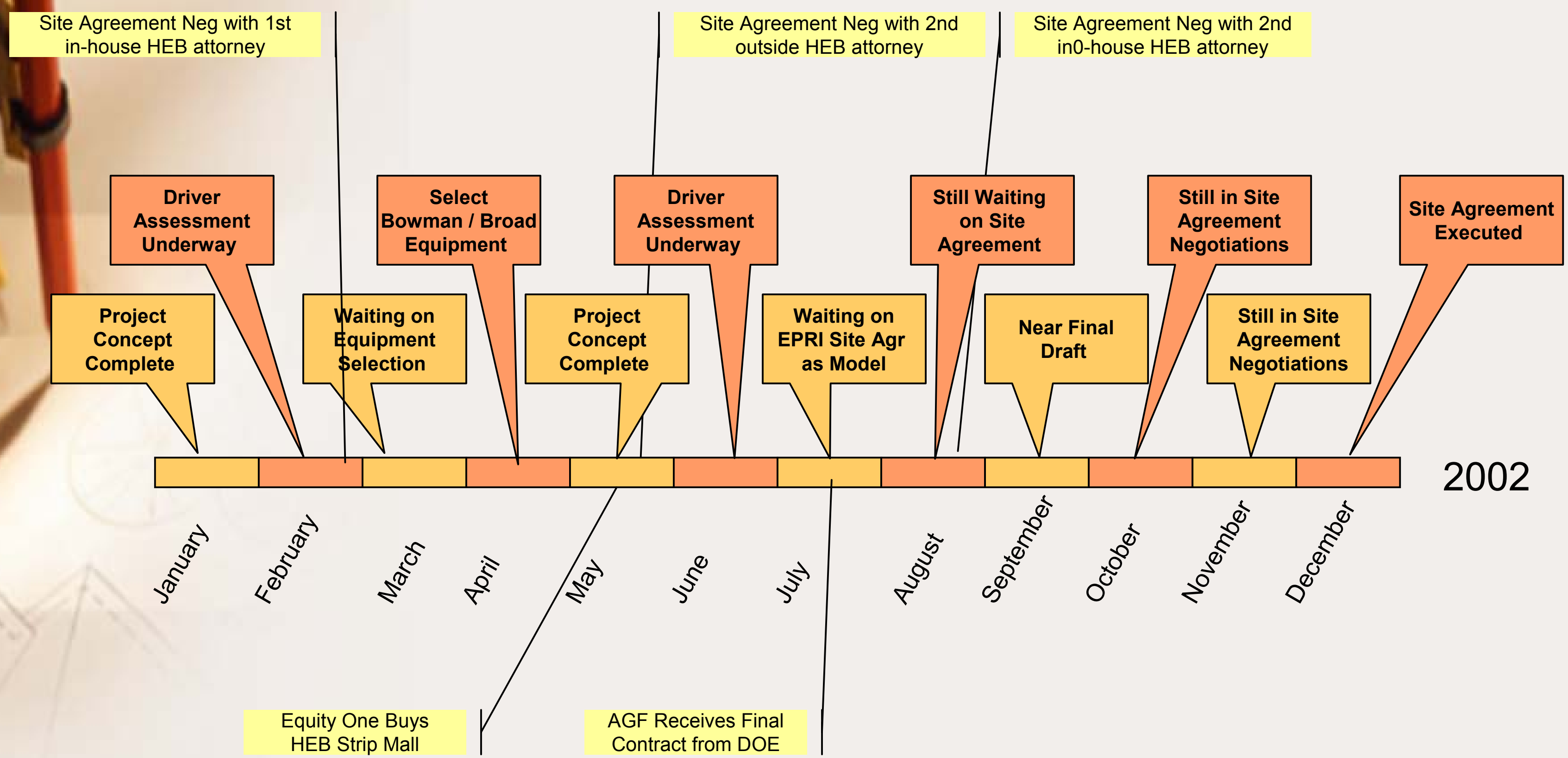


HEAT RECOVERY & EXHAUST DUCTING

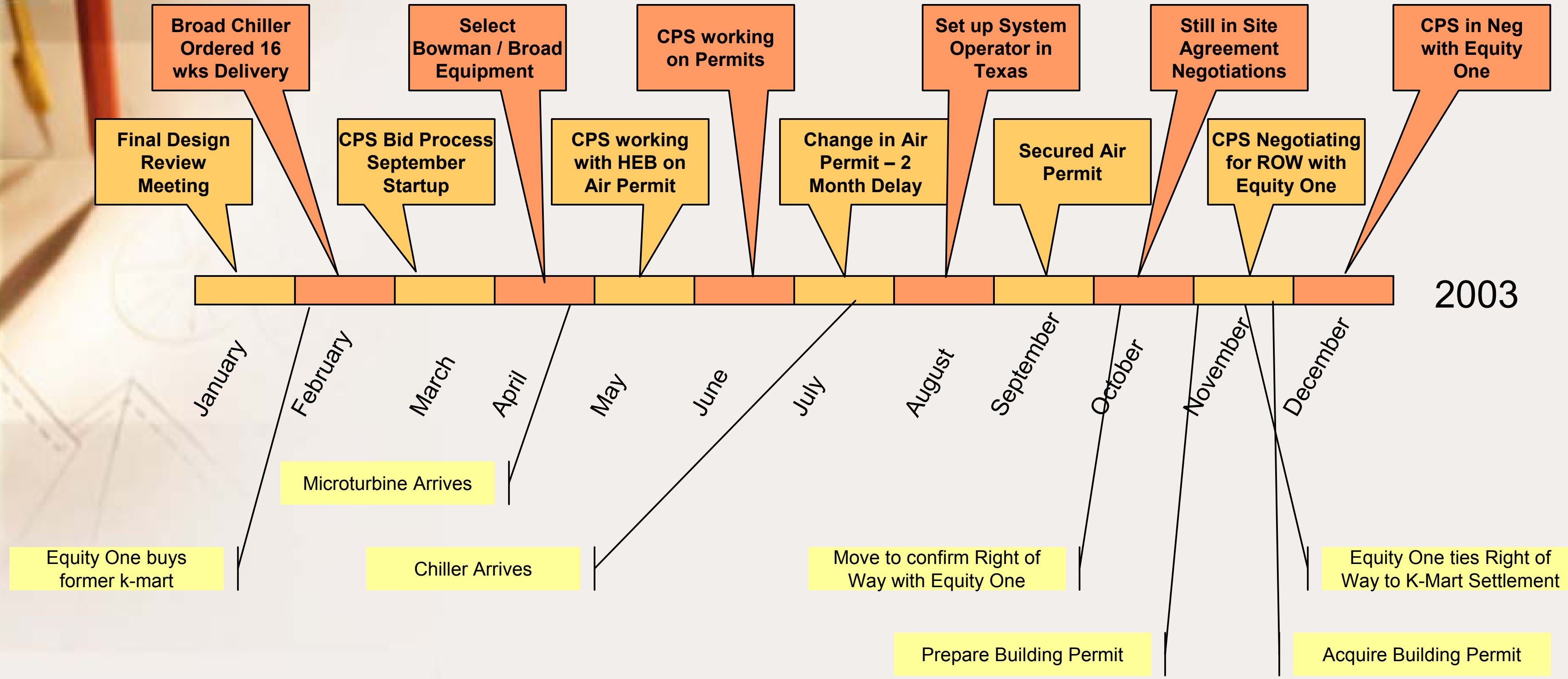
Absorption Chiller / Cooling Tower Module Ready for Installation

Microturbine Ready for Installation

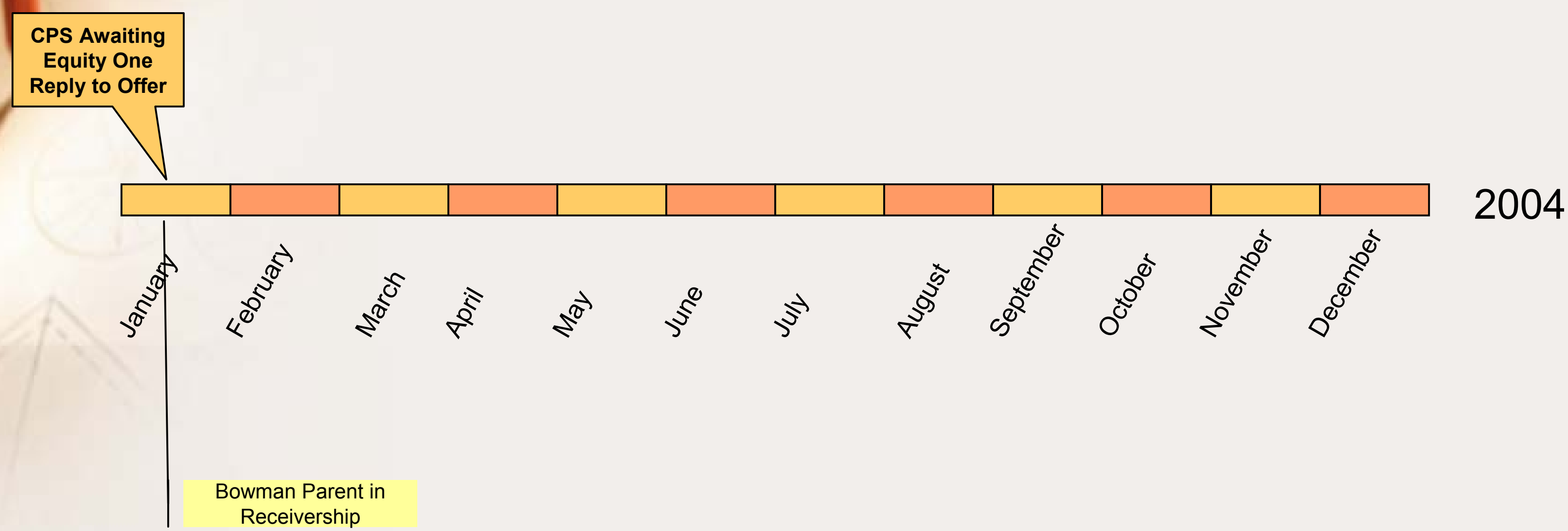
Project Timeline



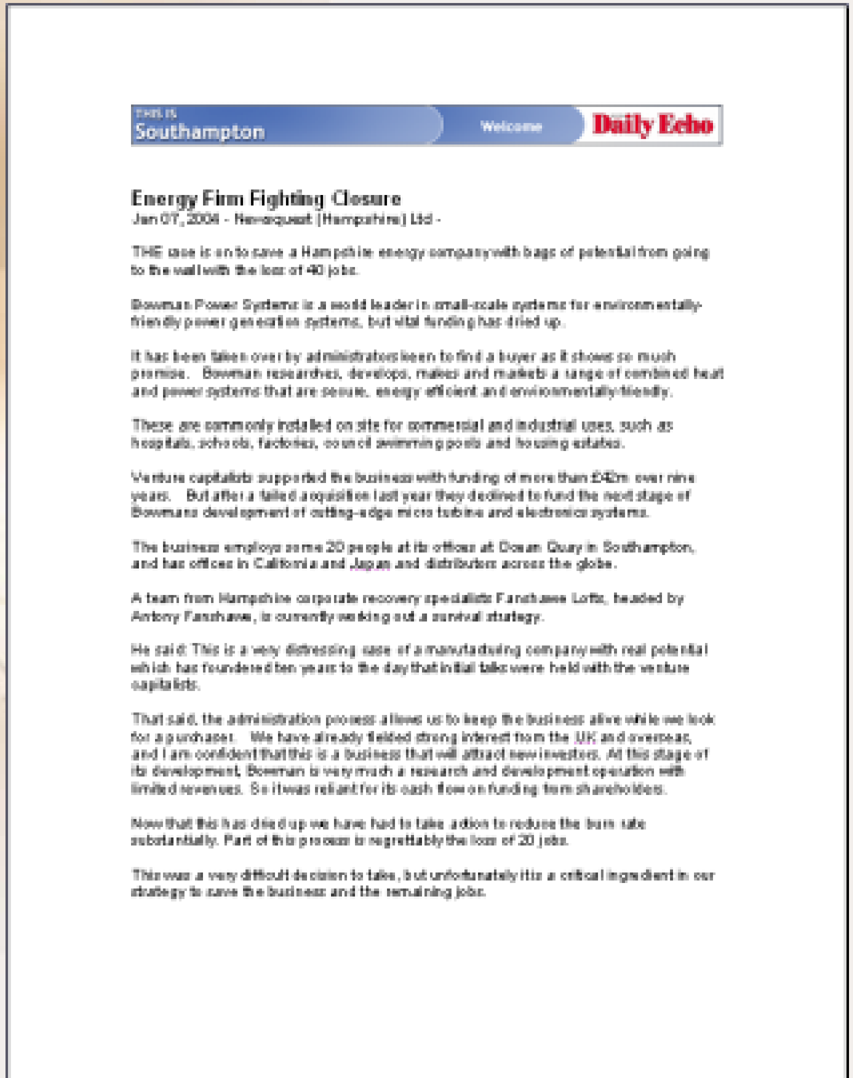
Project Timeline



Project Timeline



Current Status



THIS IS Southampton | Welcome | Daily Echo

Energy Firm Fighting Closure
Jan 07, 2004 - Newsquest (Hampshire) Ltd -

THE race is on to save a Hampshire energy company with bags of potential from going to the wall with the loss of 40 jobs.

Bowman Power Systems is a world leader in small-scale systems for environmentally-friendly power generation systems, but vital funding has dried up.

It has been taken over by administrators keen to find a buyer as it shows so much promise. Bowman researches, develops, makes and markets a range of combined heat and power systems that are secure, energy efficient and environmentally-friendly.

These are commonly installed on site for commercial and industrial uses, such as hospitals, schools, factories, council swimming pools and housing estates.

Venture capitalists supported the business with funding of more than £42m over nine years. But after a failed acquisition last year they declined to fund the next stage of Bowmans development of cutting-edge micro turbine and electronics systems.

The business employs some 20 people at its offices at Ocean Quay in Southampton, and has offices in California and Japan and distributors across the globe.

A team from Hampshire corporate recovery specialists Fanshawe Lofts, headed by Antony Fanshawe, is currently working out a survival strategy.

He said: This is a very distressing case of a manufacturing company with real potential which has foundered ten years to the day that initial talks were held with the venture capitalists.

That said, the administration process allows us to keep the business alive while we look for a purchaser. We have already fielded strong interest from the UK and overseas, and I am confident that this is a business that will attract new investors. At this stage of its development, Bowman is very much a research and development operation with limited revenues. So it was reliant for its cash flow on funding from shareholders.

Now that this has dried up we have had to take action to reduce the burn rate substantially. Part of this process is regrettably the loss of 20 jobs.

This was a very difficult decision to take, but unfortunately it is a critical ingredient in our strategy to save the business and the remaining jobs.

Thank You