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.



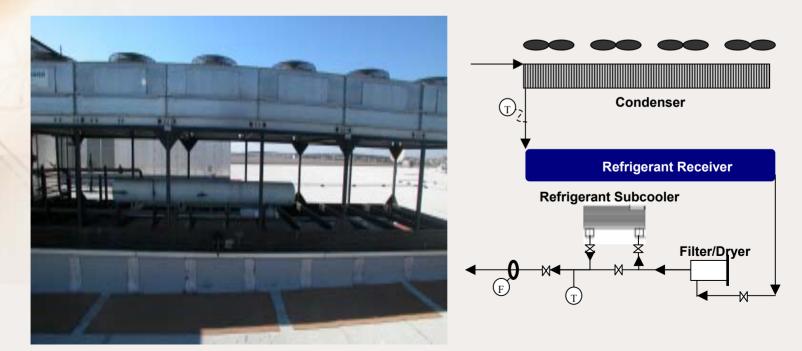
Rooftop

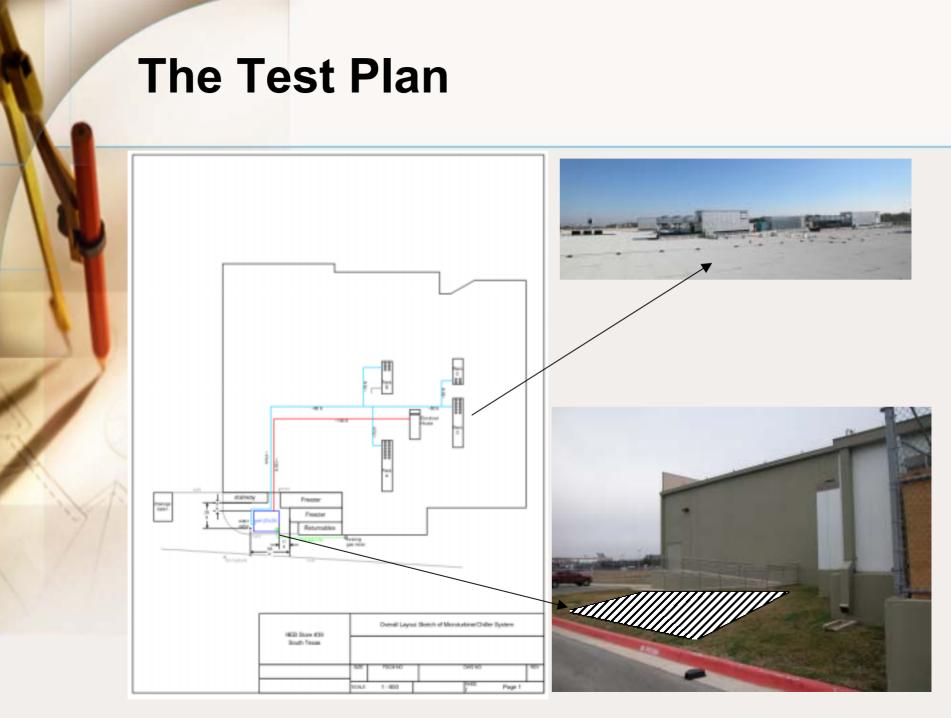
The basic premise for the test is to supply enough continuous on-site power to provide thermal energy for an absorption chiller to supply liquid refrigerant subcooling to the low temperature and medium temperature refrigeration racks.



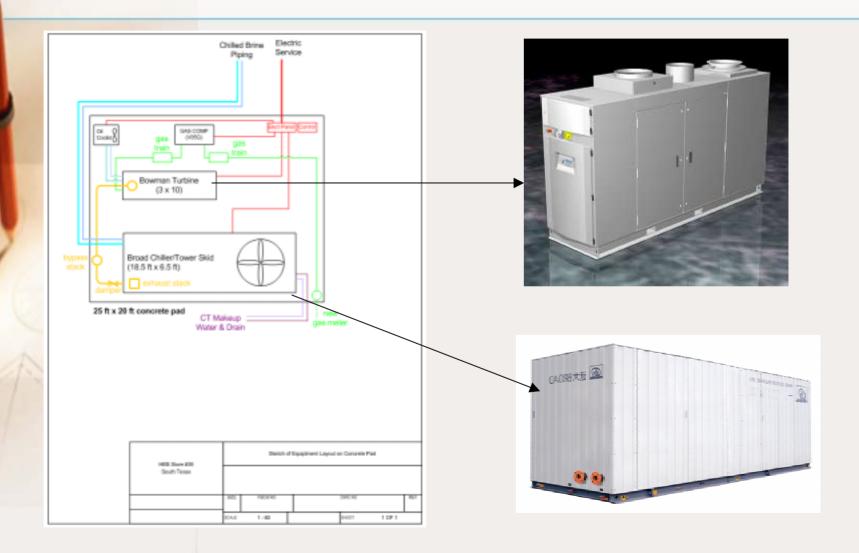
Condensing Unit

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.



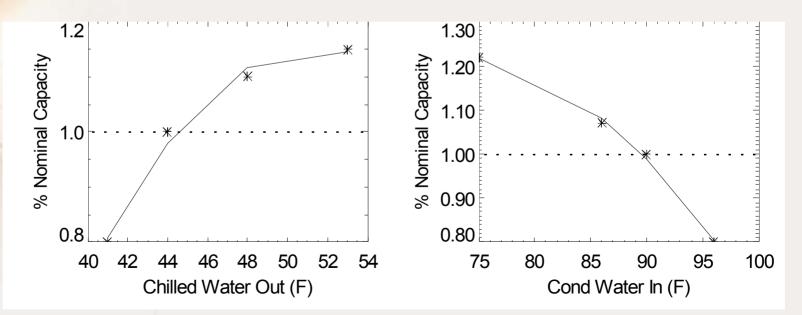


Equipment Layout



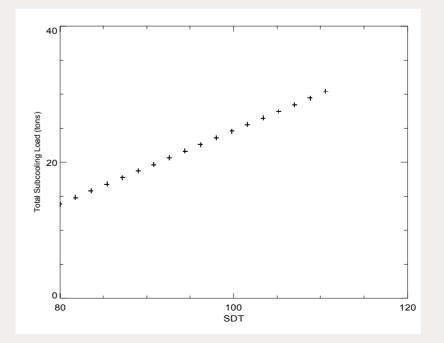
Absorption Chiller Performance

- 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

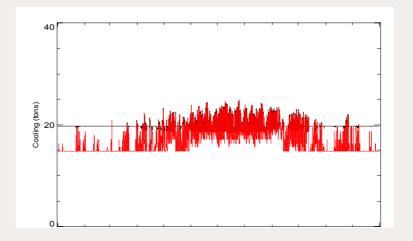
- We assume the following performance HX and chiller:
 - HX effectiveness:
- 92% (minimum flow on refrigerant side)
- Chiller capacity: 20 tons (nominal)
- Chiller delta-T: 16°F
- Chiller flow:
- 16°F (nominal)
- 30 gpm (constant; total for all HX's)

Chiller Load Calculation

Iterative calculations at peak ambient: 98.6°F (SDT = 110.6°F)

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- 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					

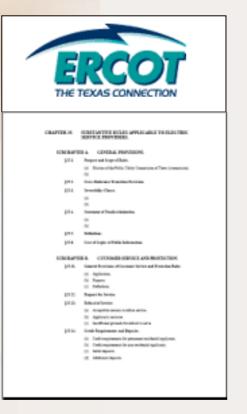
			2	5% Lower cost	35%	Lower cost +
	в	owman	<u>.</u>	Bowman		> HR Bowman
Nominal Size (kW)		80		80		80
Inlet cooling		Yes		Yes		Yes
Avg Annual Power (kW)		78		78		78
Avg Annual Efficiency (HHV)		26%		26%		26%
Annual Energy Output (kWh)		683,280		683,280		683,280
Avg Gas Consumption (therms/h)		10.4		10.4		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					

			3	5% Lower cost	35% Lower cost +
	E	<u>Bowman</u>		<u>Bowman</u>	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	\$	200,000	\$	130,000	\$ 130,000
(generation, chiller, tower +					
some controls)					
Approx Simple Payback		5.4		3.5	3.1

ISO ERCOT Transaction Meter



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TCEQ

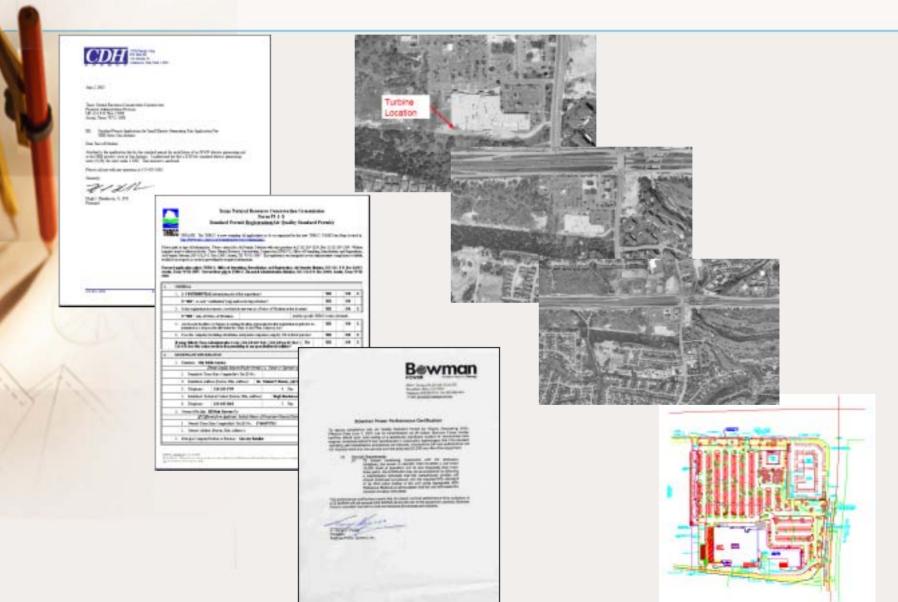
East Texas Region:

- (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]

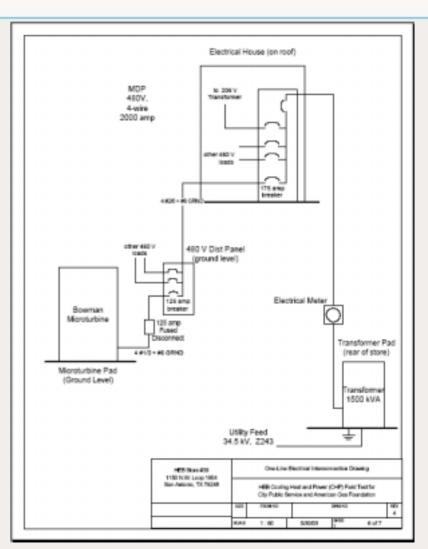
TCEQ Permit Paperwork



City of San Antonio BUILDING PERMIT APPLICATION

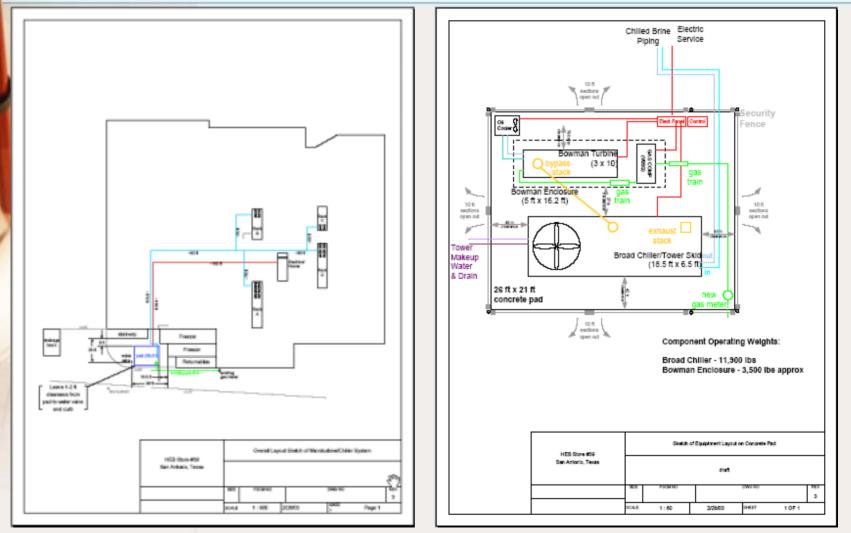
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1	Project Name:					-				
	STN ADDNES:				Surding No.:		Sufie No.1			
2	Legal Description NO	D:		Diock:		Lot(s):				
	Owner:			Phone:		Fax				
3	Address:			CHAR:			ti Mili Mili Mili Mili Mili Mili Mili Mi			
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4	Address:			Empl:		-	10 2011 2011 2011 2011 2011 2011 2011 2			
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c	ADOTHS:			Empl:						
	City:	alay:			Zip Code	К.,	1			
	Contact Person:			Phone:		Fax				
7	Address:			Engl:		-				
	City:			State:	Zip Code					
8	Class of Work (circle as approp	tate): g	New Studure		Addition	in				
	Flood Repairs Tes	NO		Other (De	(adrow)					
	Occupancy Classification (per UBC):			Building L	Sufering Like:					
	Construction Type (per UBC):									
-	Existing Square Footage:		New Square Fostage:							
		want (rt.)		Hergelt to Higherel Proor (L):						
10	Change of Use From:			1	-					
11	Other Hork to be Done (sincle a	s appropriate):	M	echanical						
12	Water Analiable? Yes	N	ė –	Sever Ava	NDR7 Y	- 49		NO		
13	Existing Structures on Site?		Yes				No			
14	Have you had a Preliminary Pla	1.00								
-	If 60, when?	Pretminary Plan Review #:								
15	Will alcoholic beverages be solo	i an premises?		Yes			Nip			
16	Valuation:									
	Existing the sprinkler system?	Yes	NB		тте крллжег сус		Yes	NO		
	Existing stancpipe system?	Yes	Na		i stancpipe syster		Yes	No		
	Existing fire alarm system?	Yes.	No	Ргоровно	the alarm system	52	Yes.	No		
17	Existing selection system?	Yes	NO	Propose	detection system	17	Yes	NO		
	Existing smoke control?	Yes	No		smoke control?		Yes	No		
	Existing other?	Yes.	No	Propose	i other?		Yes	No		
	List other:			List offrer		_				

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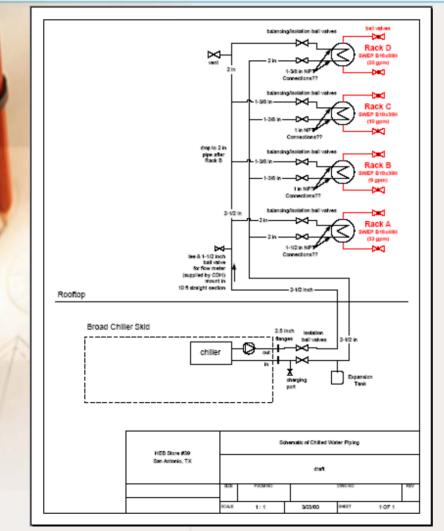
ELECTRICAL ONE LINE

APPLICATION

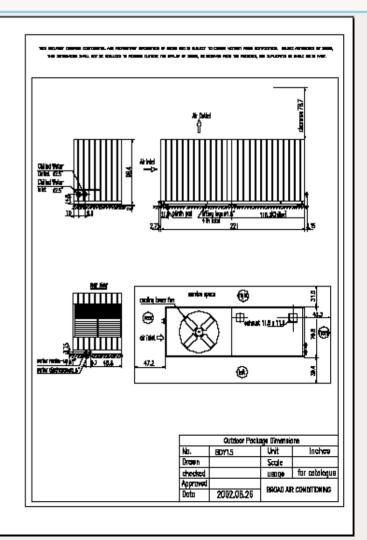


GENERAL PROJECT LAYOUT

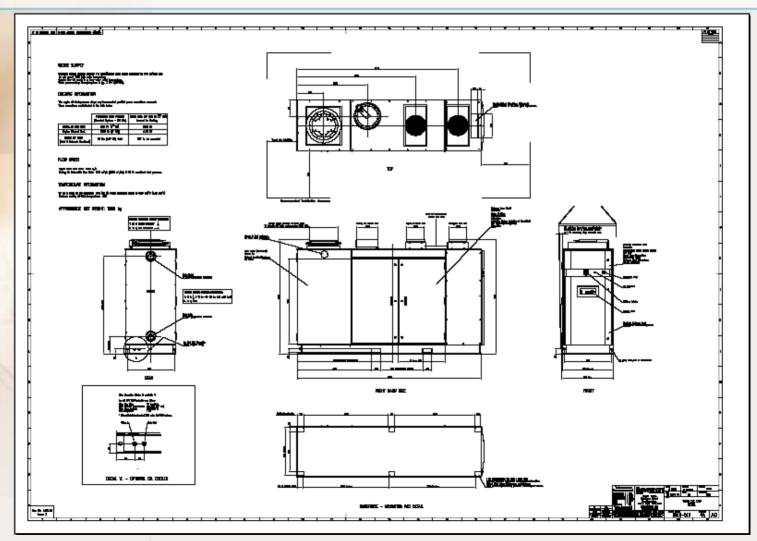
EQUIPMENT PAD LAYOUT



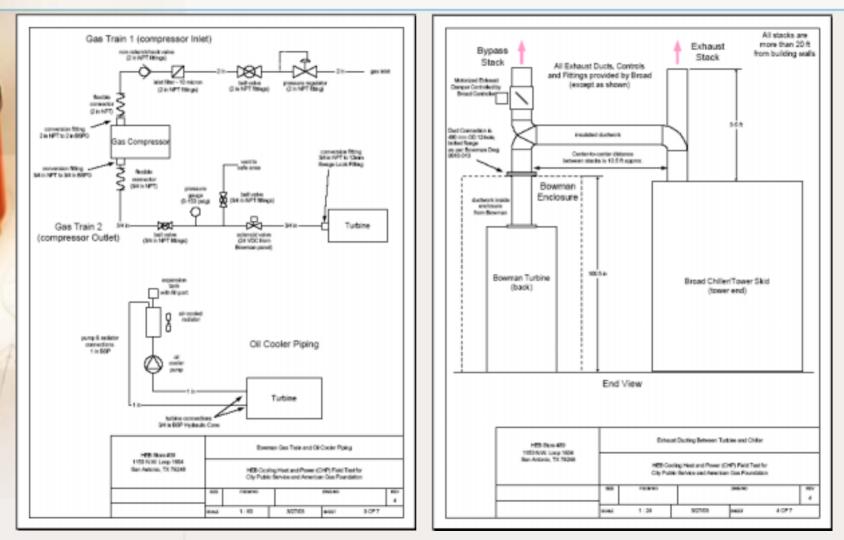




CHILLER MODULE



MICROTURBINE



GAS TRAIN & OIL PIPING

HEAT RECOVERY & EXHAUST DUCTING

Absorption Chiller / Cooling Tower Module Ready for Installation









Microturbine Ready for Installation

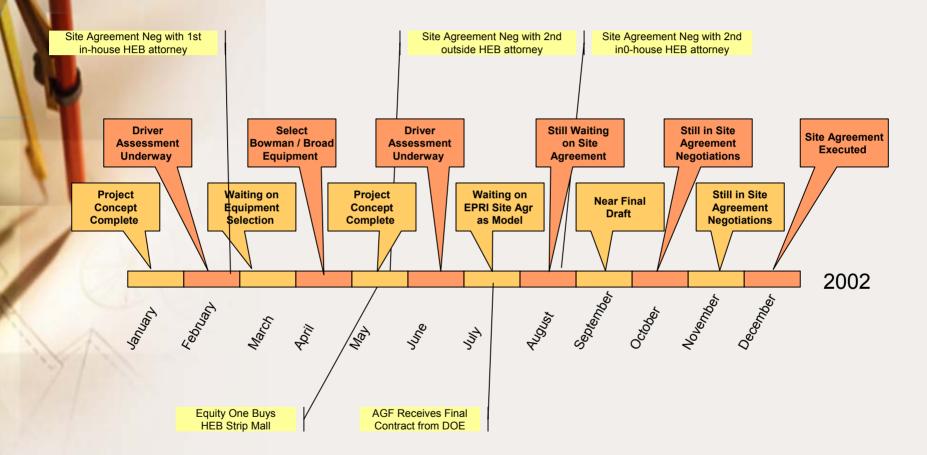




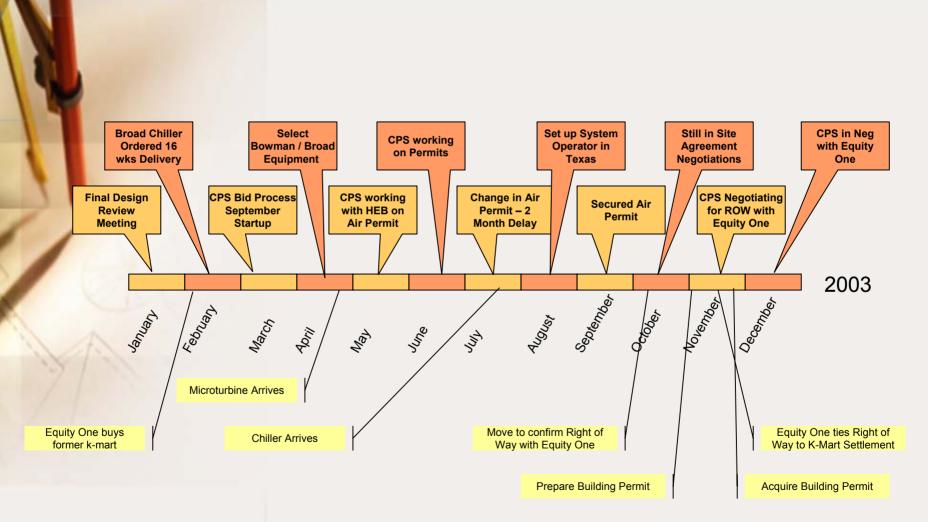




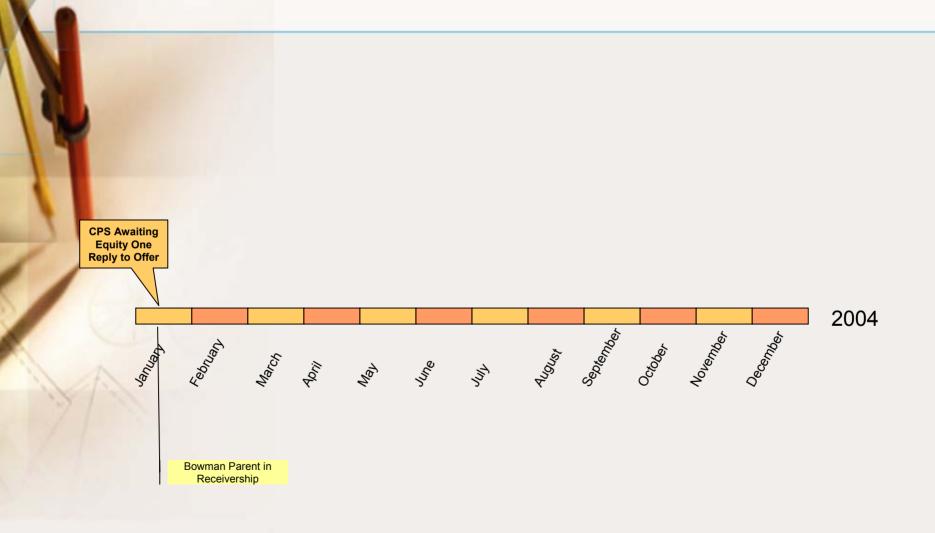
Project Timeline



Project Timeline



Project Timeline



Current Status



---- Daily Echo

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

THE case is on to cave 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 environmentallyfriendly power generation systems, but vital funding has dried up.

It has been taken over by administratorskeen to find a buyer as it shows so much promise. Bowman researches, develops, makes and markets a range of cembin of heat and power systems that are so use, energy efficient and environmentally/filesdly.

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

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

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

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

He said: This is a very distressing case of a manutadusing company with real potential which has foundered ben years to the day that initial take 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 developments. So it was reliant for its each flow on funding terms hareholders.

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 studegy to save the business and the remaining jobs.



Thank You

