Imagination is more important than knowledge
- Albert Einstein

REWARDING EFFICIENCY: Clean Energy *via* resilient and sustainable Combined Heating & Power (CHP) system

Combined Heat & Power (CHP) options for _____

Cut cost of energy & water
Cut Greenhouse Gas Emissions (GHG)
Increase resiliency = (redundancy, availability)

Suresh Jambunathan
630-335-4544
suresh.jambunathan@enwadev.com

Inside-the-fence CHP project Executive Summary

_____ site offers an economically attractive (i.e. *financeable*), technically robust, environmentally friendly, load-scalable &supply-resilient opportunity for an efficient natural gas Combined Heat & Power (CHP) project.

Options to improve Return on Invested Capital (ROIC) include the 10% Investment Tax Credit (ITC), avoided/reduced investment on thermal & electrical infrastructure, 3rd party financing, project leverage etc… The project also creates an option for C-credits *plus* potential to reduce site water intensity (not in this scope).

A Project Execution Plan (PEP) will layout the critical path to tighten an anticipated 10-to-16 months schedule from Limited Notice to Proceed (LNTP) to Commercial Operations Date (COD).

Project risks can be mitigated with a robust PEP and early milestones should include co-ordination with local utility, soliciting community support & engagement with local permitting authorities.

_____can significantly boost CHP project economics by selling heat (i.e. hot water) to Industrial Facility (IF) on the north. External energy sale demonstrates ingenuity & community spirit, increases sustainability *and* supply side resiliency of the IF.

Screen shot of site

Sell CHP waste heat to Industrial Facility; boost CHP efficiency *and* secure high-margin incremental revenue

Close up Screen shot of CHP location

Install CHP at _____plant

BASE CASE economic summary: 10-year CHP project horizon

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	50%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	7.6	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	10	
Equity:Debt Ratio	%	100%	assumed
Debt Term	years	12	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	125	assumed

Sized & modeled 3-alternate CHP configurations

CHP saves site energy expense (power + fuel), reduces emissions and increases supply side resiliency.

Comparable emissions reductions & efficiencies across all CHP configurations

- 2 x Reciprocating Engine CHP has lowest first cost.
- 1 x Gas Turbine CHP has highest lifetime savings.

No conflict between wallet & conscience !

		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/KW$_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$5.9	$9.9	$9.2
****Equity-Multiple of Investment (MOI)**		**-**	**1.1**	**0.8**	**1.2**
*****Site Energy Expense**					
Year 1	$MM	$3.0	$2.2	$2.2	$2.0
Year 10	$MM	$31	$24	$23	$20
Cum. %redn. 10 yrs	% reduction	0%	-22%	-26%	-34%
Emissions					
From grid power	mt CO_2	22,184	4,641	1,652	3,246
From fuel to Blrs	mt CO_2	10,264	6,987	360	699
From fuel to CHP	mt CO_2	-	11,004	21,434	19,395
TOTAL site emissions	**mt CO_2**	**32,448**	**22,633**	**23,446**	**23,340**
Emissions reduction	% change	0%	-30%	-28%	-28%
CHP technical					
CHP capacity	KW$_e$	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	61.3%	60.4%	63.4%
Thermal Utilization	%		63%	64%	77%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	193,164	131,494	6,769	13,161
Fuel to CHP	MMBtu	-	207,094	403,375	365,005
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**193,164**	**338,587**	**410,144**	**378,166**
Elec. From grid	MWh	28,093	5,877	2,093	4,110
Elec. From CHP	MWh	-	22,215	26,000	23,982
TOTAL Elec. (CHP + grid)	**MWh**	**28,093**	**28,093**	**28,093**	**28,093**

NOTES:

*Pjt Inv. w/10%ITC = CHP only investment *less* 10% ITC. Excludes credit for *avoided* CapEx for blrs, elec. Infra. Etc..

** Equity MOI = (Cumulative project cash / Equity only investment)

***power + fuel + O&M + Debt. Service

CHP Operations & Maintenance proforma: vendor quotes + reasonable assumptions

	OPERATIONS & MAINTENANCE EXPENSE			CHP as 2 x JMS420		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
						0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	INFLATION																									
	Equipment / Maintenance assets				%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
	Labor /staff				%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
A	# MAINTENANCE	$/Fired hour/unit	Maint/yr																							
	~~Gas Turbine~~	-	$0.00		$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	~~RE-HRSG~~	-	$0.00		$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Gas Compressor	-	$0.00		$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Reciprocating Engine	$27.68	$460,706		$	$460,706	$467,617	$474,631	$481,750	$488,976	$496,311	$503,756	$511,312	$518,982	$526,767	$534,668	$542,688	$550,828	$559,091	$567,477	$575,989	$584,629	$593,399	$602,300	$611,334	$620,504
	Reciprocating Engine MAJOR OVERHAUL at 60000 Optg Hrs				$	$0	$0	$0	$0	$0	$0	$0	$0	$989,060	$0	$0	$0	$0	$0	$0	$0	$1,114,169	$0	$0	$0	$0
	RE-HRSG/HRU	-	$15,000		$	$15,000	$15,225	$15,453	$15,685	$15,920	$16,159	$16,402	$16,648	$16,897	$17,151	$17,408	$17,669	$17,934	$18,203	$18,476	$18,753	$19,035	$19,320	$19,610	$19,904	$20,203
	Other	-	$5,000		$	$5,000	$5,075	$5,151	$5,228	$5,307	$5,386	$5,467	$5,549	$5,632	$5,717	$5,803	$5,890	$5,978	$6,068	$6,159	$6,251	$6,345	$6,440	$6,537	$6,635	$6,734
	SUB-TOTAL # MAINTENANCE				**$**	**$480,706**	**$487,917**	**$495,235**	**$502,664**	**$510,204**	**$517,857**	**$525,625**	**$533,509**	**$1,530,572**	**$549,634**	**$557,879**	**$566,247**	**$574,741**	**$583,362**	**$592,112**	**$600,994**	**$1,724,178**	**$619,159**	**$628,446**	**$637,873**	**$647,441**
B	# CONSUMABLES																									
	Emissons Control System (ECS) chemicals		$20,000		$	$20,000	$20,300	$20,605	$20,914	$21,227	$21,546	$21,869	$22,197	$22,530	$22,868	$23,211	$23,559	$23,912	$24,271	$24,635	$25,005	$25,380	$25,760	$26,147	$26,539	$26,937
	Other - misc		$10,000			$10,000	$10,150	$10,302	$10,457	$10,614	$10,773	$10,934	$11,098	$11,265	$11,434	$11,605	$11,779	$11,956	$12,136	$12,318	$12,502	$12,690	$12,880	$13,073	$13,270	$13,469
	SUB-TOTAL # CONSUMABLES					**$30,000**	**$30,450**	**$30,907**	**$31,370**	**$31,841**	**$32,319**	**$32,803**	**$33,295**	**$33,795**	**$34,302**	**$34,816**	**$35,338**	**$35,869**	**$36,407**	**$36,953**	**$37,507**	**$38,070**	**$38,641**	**$39,220**	**$39,809**	**$40,406**
						2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
C	# OPERATIONS	% reqd.	$/hr	UNIT $/yr		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Energy systems manager	25%	$60	124,800	$	$31,200	$31,980	$32,780	$33,599	$34,439	$35,300	$36,182	$37,087	$38,014	$38,965	$39,939	$40,937	$41,961	$43,010	$44,085	$45,187	$46,317	$47,474	$48,661	$49,878	$51,125
3	Operators	10%	$40	83,200	$	$24,960	$25,584	$26,224	$26,879	$27,551	$28,240	$28,946	$29,670	$30,411	$31,172	$31,951	$32,750	$33,568	$34,408	$35,268	$36,150	$37,053	$37,980	$38,929	$39,902	$40,900
3	Maintenance	10%	$50	104,000	$	$31,200	$31,980	$32,780	$33,599	$34,439	$35,300	$36,182	$37,087	$38,014	$38,965	$39,939	$40,937	$41,961	$43,010	$44,085	$45,187	$46,317	$47,474	$48,661	$49,878	$51,125
1	Admin. Asst.	25%	$25	52,000	$	$13,000	$13,325	$13,658	$14,000	$14,350	$14,708	$15,076	$15,453	$15,839	$16,235	$16,641	$17,057	$17,484	$17,921	$18,369	$18,828	$19,299	$19,781	$20,276	$20,782	$21,302
0	other	0%	$20	41,600	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUB-TOTAL # OPERATIONS				**$**	**$100,360**	**$102,869**	**$105,441**	**$108,077**	**$110,779**	**$113,548**	**$116,387**	**$119,297**	**$122,279**	**$125,336**	**$128,469**	**$131,681**	**$134,973**	**$138,347**	**$141,806**	**$145,351**	**$148,985**	**$152,710**	**$156,527**	**$160,441**	**$164,452**
A+B+C	**TOTAL O&M**				**$**	**$611,066**	**$621,236**	**$631,583**	**$642,111**	**$652,823**	**$663,723**	**$674,815**	**$686,101**	**$1,686,646**	**$709,272**	**$721,164**	**$733,267**	**$745,582**	**$758,116**	**$770,871**	**$783,852**	**$1,911,233**	**$810,509**	**$824,194**	**$838,122**	**$852,298**

	OPERATIONS & MAINTENANCE EXPENSE			CHP as 1 x Centaur40		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
						0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	INFLATION																									
	Equipment / Maintenance assets				%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
	Labor /staff				%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
A	# MAINTENANCE	$/Fired hour/unit	Maint/yr																							
	Gas Turbine	$32.00	$266,304		$	$266,304	$270,299	$274,353	$278,468	$282,645	$286,885	$291,188	$295,556	$299,989	$304,489	$309,057	$313,693	$318,398	$323,174	$328,021	$332,942	$337,936	$343,005	$348,150	$353,372	$358,673
	GT-HRSG	-	$15,000		$	$15,000	$15,225	$15,453	$15,685	$15,920	$16,159	$16,402	$16,648	$16,897	$17,151	$17,408	$17,669	$17,934	$18,203	$18,476	$18,753	$19,035	$19,320	$19,610	$19,904	$20,203
	Gas Compressor	-	$5,000		$	$5,000	$5,075	$5,151	$5,228	$5,307	$5,386	$5,467	$5,549	$5,632	$5,717	$5,803	$5,890	$5,978	$6,068	$6,159	$6,251	$6,345	$6,440	$6,537	$6,635	$6,734
	~~Reciprocating Engine~~	-	$0.00		$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Gas Turbine MAJOR OVERHAUL at 35000 Optg Hrs				$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	~~RE-HRSG/HRU~~	-	$0.00		$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Other	-	$5,000		$	$5,000	$5,075	$5,151	$5,228	$5,307	$5,386	$5,467	$5,549	$5,632	$5,717	$5,803	$5,890	$5,978	$6,068	$6,159	$6,251	$6,345	$6,440	$6,537	$6,635	$6,734
	SUB-TOTAL # MAINTENANCE				**$**	**$291,304**	**$295,674**	**$300,109**	**$304,610**	**$309,179**	**$313,817**	**$318,524**	**$323,302**	**$328,152**	**$333,074**	**$338,070**	**$343,141**	**$348,288**	**$353,513**	**$358,815**	**$364,198**	**$369,661**	**$375,205**	**$380,834**	**$386,546**	**$392,344**
B	# CONSUMABLES																									
	Emissons Control System (ECS) chemicals		$20,000		$	$20,000	$20,300	$20,605	$20,914	$21,227	$21,546	$21,869	$22,197	$22,530	$22,868	$23,211	$23,559	$23,912	$24,271	$24,635	$25,005	$25,380	$25,760	$26,147	$26,539	$26,937
	Other - misc		$10,000			$10,000	$10,150	$10,302	$10,457	$10,614	$10,773	$10,934	$11,098	$11,265	$11,434	$11,605	$11,779	$11,956	$12,136	$12,318	$12,502	$12,690	$12,880	$13,073	$13,270	$13,469
	SUB-TOTAL # CONSUMABLES					**$30,000**	**$30,450**	**$30,907**	**$31,370**	**$31,841**	**$32,319**	**$32,803**	**$33,295**	**$33,795**	**$34,302**	**$34,816**	**$35,338**	**$35,869**	**$36,407**	**$36,953**	**$37,507**	**$38,070**	**$38,641**	**$39,220**	**$39,809**	**$40,406**
						2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
C	# OPERATIONS	% reqd.	$/hr	UNIT $/yr		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Energy systems manager	25%	$60	124,800	$	$31,200	$31,980	$32,780	$33,599	$34,439	$35,300	$36,182	$37,087	$38,014	$38,965	$39,939	$40,937	$41,961	$43,010	$44,085	$45,187	$46,317	$47,474	$48,661	$49,878	$51,125
3	Operators	10%	$40	83,200	$	$24,960	$25,584	$26,224	$26,879	$27,551	$28,240	$28,946	$29,670	$30,411	$31,172	$31,951	$32,750	$33,568	$34,408	$35,268	$36,150	$37,053	$37,980	$38,929	$39,902	$40,900
3	Maintenance	10%	$50	104,000	$	$31,200	$31,980	$32,780	$33,599	$34,439	$35,300	$36,182	$37,087	$38,014	$38,965	$39,939	$40,937	$41,961	$43,010	$44,085	$45,187	$46,317	$47,474	$48,661	$49,878	$51,125
1	Admin. Asst.	25%	$25	52,000	$	$13,000	$13,325	$13,658	$14,000	$14,350	$14,708	$15,076	$15,453	$15,839	$16,235	$16,641	$17,057	$17,484	$17,921	$18,369	$18,828	$19,299	$19,781	$20,276	$20,782	$21,302
0	other	0%	$20	41,600	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUB-TOTAL # OPERATIONS				**$**	**$100,360**	**$102,869**	**$105,441**	**$108,077**	**$110,779**	**$113,548**	**$116,387**	**$119,297**	**$122,279**	**$125,336**	**$128,469**	**$131,681**	**$134,973**	**$138,347**	**$141,806**	**$145,351**	**$148,985**	**$152,710**	**$156,527**	**$160,441**	**$164,452**
A+B+C	**TOTAL O&M**				**$**	**$421,664**	**$428,993**	**$436,456**	**$444,057**	**$451,799**	**$459,684**	**$467,715**	**$475,894**	**$484,225**	**$492,712**	**$501,356**	**$510,161**	**$519,130**	**$528,267**	**$537,574**	**$547,056**	**$556,715**	**$566,556**	**$576,581**	**$586,795**	**$597,201**

	OPERATIONS & MAINTENANCE EXPENSE			CHP as 2 x OPRA16		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
						0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	INFLATION																									
	Equipment / Maintenance assets				%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
	Labor /staff				%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
A	# MAINTENANCE	$/Fired hour/unit	Maint/yr																							
	Gas Turbine	$35.00	$594,804		$	$594,804	$603,726	$612,782	$621,974	$631,303	$640,773	$650,384	$660,140	$670,042	$680,093	$690,294	$700,649	$711,158	$721,826	$732,653	$743,643	$754,798	$766,120	$777,611	$789,276	$801,115
	GT-HRSG	-	$15,000		$	$15,000	$15,225	$15,453	$15,685	$15,920	$16,159	$16,402	$16,648	$16,897	$17,151	$17,408	$17,669	$17,934	$18,203	$18,476	$18,753	$19,035	$19,320	$19,610	$19,904	$20,203
	Gas Compressor	-	$5,000		$	$5,000	$5,075	$5,151	$5,228	$5,307	$5,386	$5,467	$5,549	$5,632	$5,717	$5,803	$5,890	$5,978	$6,068	$6,159	$6,251	$6,345	$6,440	$6,537	$6,635	$6,734
	~~Reciprocating Engine~~	-	$0.00		$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Gas Turbine MAJOR OVERHAUL at 40000 Optg Hrs				$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	~~RE-HRSG/HRU~~	-	$0.00		$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Other	-	$5,000		$	$5,000	$5,075	$5,151	$5,228	$5,307	$5,386	$5,467	$5,549	$5,632	$5,717	$5,803	$5,890	$5,978	$6,068	$6,159	$6,251	$6,345	$6,440	$6,537	$6,635	$6,734
	SUB-TOTAL # MAINTENANCE				**$**	**$619,804**	**$629,101**	**$638,538**	**$648,116**	**$657,837**	**$667,705**	**$677,721**	**$687,886**	**$698,205**	**$708,678**	**$719,308**	**$730,097**	**$741,049**	**$752,165**	**$763,447**	**$774,899**	**$786,522**	**$798,320**	**$810,295**	**$822,449**	**$834,786**
B	# CONSUMABLES																									
	Emissons Control System (ECS) chemicals		$20,000		$	$20,000	$20,300	$20,605	$20,914	$21,227	$21,546	$21,869	$22,197	$22,530	$22,868	$23,211	$23,559	$23,912	$24,271	$24,635	$25,005	$25,380	$25,760	$26,147	$26,539	$26,937
	Other - misc		$10,000			$10,000	$10,150	$10,302	$10,457	$10,614	$10,773	$10,934	$11,098	$11,265	$11,434	$11,605	$11,779	$11,956	$12,136	$12,318	$12,502	$12,690	$12,880	$13,073	$13,270	$13,469
	SUB-TOTAL # CONSUMABLES					**$30,000**	**$30,450**	**$30,907**	**$31,370**	**$31,841**	**$32,319**	**$32,803**	**$33,295**	**$33,795**	**$34,302**	**$34,816**	**$35,338**	**$35,869**	**$36,407**	**$36,953**	**$37,507**	**$38,070**	**$38,641**	**$39,220**	**$39,809**	**$40,406**
						2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
C	# OPERATIONS	% reqd.	$/hr	UNIT $/yr		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Energy systems manager	25%	$60	124,800	$	$31,200	$31,980	$32,780	$33,599	$34,439	$35,300	$36,182	$37,087	$38,014	$38,965	$39,939	$40,937	$41,961	$43,010	$44,085	$45,187	$46,317	$47,474	$48,661	$49,878	$51,125
3	Operators	10%	$40	83,200	$	$24,960	$25,584	$26,224	$26,879	$27,551	$28,240	$28,946	$29,670	$30,411	$31,172	$31,951	$32,750	$33,568	$34,408	$35,268	$36,150	$37,053	$37,980	$38,929	$39,902	$40,900
3	Maintenance	10%	$50	104,000	$	$31,200	$31,980	$32,780	$33,599	$34,439	$35,300	$36,182	$37,087	$38,014	$38,965	$39,939	$40,937	$41,961	$43,010	$44,085	$45,187	$46,317	$47,474	$48,661	$49,878	$51,125
1	Admin. Asst.	25%	$25	52,000	$	$13,000	$13,325	$13,658	$14,000	$14,350	$14,708	$15,076	$15,453	$15,839	$16,235	$16,641	$17,057	$17,484	$17,921	$18,369	$18,828	$19,299	$19,781	$20,276	$20,782	$21,302
0	other	0%	$20	41,600	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUB-TOTAL # OPERATIONS				**$**	**$100,360**	**$102,869**	**$105,441**	**$108,077**	**$110,779**	**$113,548**	**$116,387**	**$119,297**	**$122,279**	**$125,336**	**$128,469**	**$131,681**	**$134,973**	**$138,347**	**$141,806**	**$145,351**	**$148,985**	**$152,710**	**$156,527**	**$160,441**	**$164,452**
A+B+C	**TOTAL O&M**				**$**	**$750,164**	**$762,420**	**$774,885**	**$787,563**	**$800,457**	**$813,572**	**$826,911**	**$840,478**	**$854,278**	**$868,315**	**$882,593**	**$897,117**	**$911,891**	**$926,919**	**$942,206**	**$957,757**	**$973,577**	**$989,670**	**$1,006,043**	**$1,022,698**	**$1,039,643**

INPUTS:

Inflation rate

Maintenance expense major equipment
- Preventive maintenance
- Major overhauls covered by
  - vendor LTSA (gas turbines) *or*
  - scheduled expense (engine)

Operations staff:
- number needed
- % of time required
- wage/salary

Room to negotiate & significantly reduce maintenance expense, especially for the reciprocating engine CHP; savings directly accrue to operations cash flow

CHP proforma Discounted Cash Flow (DCF) model; financials directly linked to technical

			2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	INFLATION																						
	Natural Gas at burner tip	%		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
	Grid power price	%		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
	Pkge Blrs only: O&M Variable charge	%		1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
	HOST ENERGY LOADS																						
	Capacity Factor: Power	%		64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%	64.5%
	Power peak	MW_e	4.951	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
		MWh	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093	28,093
	Capacity Factor: Thermal	%		47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%	47.7%
	Thermal Energy PEAK	$MMBtu_{th}$ / Hr	38.388	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4
		$MMBtu_{th}$	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326	160,326
	Host's Power:Heat Ratio			**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**
No CHP	Nat Gas to Boiler	HHV $MMBtu_{th}$		46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
No CHP	Nat Gas to Boiler	HHV MMBtu		193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164	193,164
No CHP	**CO2 EMISSIONS**																						
	CO2 from grid power	mt CO_2	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184	22,184
	CO2 from fuel to boilers	mt CO_2	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264
	CO2 from fuel to CHP	mt CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NO-CHP: Total CO2 emissions	mt CO_2	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**	**32,448**
	UNIT CHARGES																						
No CHP	Grid Power Price	c/KWh	**7.6**	7.6	7.7	7.7	7.8	7.8	7.8	7.9	7.9	7.9	8.0	8.0	8.1	8.1	8.1	8.2	8.2	8.3	8.3	8.4	8.4
No CHP	Grid Power Price	$/MWh	$76.0	$76.4	$76.8	$77.1	$77.5	$77.9	$78.3	$78.7	$79.1	$79.5	$79.9	$80.3	$80.7	$81.1	$81.5	$81.9	$82.3	$82.7	$83.1	$83.6	$84.0
	Natural Gas at burner tip	$/MMBtu, HHV	$2.76	$2.77	$2.79	$2.80	$2.82	$2.83	$2.84	$2.86	$2.87	$2.89	$2.90	$2.92	$2.93	$2.94	$2.96	$2.97	$2.99	$3.00	$3.02	$3.03	$3.05
No CHP	Boilers: Operations & Maintenance (O&M)																						
No CHP	Boilers: Fixed Charge	$MM	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10
No CHP	Boilers: Variable Charge	$MM		$0.20	$0.20	$0.21	$0.21	$0.21	$0.21	$0.21	$0.22	$0.22	$0.22	$0.22	$0.23	$0.23	$0.23	$0.23	$0.23	$0.24	$0.24	$0.24	$0.24
No CHP	Boilers:Total O&M Cost	$MM		$0.30	$0.30	$0.31	$0.31	$0.31	$0.31	$0.31	$0.32	$0.32	$0.32	$0.32	$0.33	$0.33	$0.33	$0.33	$0.33	$0.34	$0.34	$0.34	$0.34
	Boilers:Total O&M Cost	$/MMBtu		$1.89	$1.90	$1.91	$1.92	$1.94	$1.95	$1.96	$1.98	$1.99	$2.00	$2.02	$2.03	$2.05	$2.06	$2.07	$2.09	$2.10	$2.12	$2.13	$2.15
	METRICS for RE-CHP																						
w/RE-CHP	Full-Load Optg Hrs	Hrs		8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322
w/RE-CHP	CHP peak power PEAK	MW_e		**2.86**	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
w/RE-CHP	CHP electricity supplied	MWh	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215
	Avg. CHP thermal Energy sold	MMBtu/Hr		6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
	Annual CHP thermal Energy sold	MMBtu	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186
	Avg. Fuel to CHP Engines	HHV MMBtu/Hr	Reconcile	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
	Annual Fuel to CHP Engines	HHV MMBtu	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094
	RE-CHP: Fraction of Host load supplied																						
	% Electricity from RE-CHP	% from CHP		79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%
	% Thermal Energy from RE-CHP	% from CHP		31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%
w/RE-CHP	CHP Efficiency	% HHV		61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
w/RE-CHP	CHP Heat Rate	HHV MMBtu/MWh		6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
w/RE-CHP	CHP Thermal Energy Rate	HHV MMBtu/$MMBtu_{th}$		2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
w/RE-CHP	Operations & Maintenance (O&M)																						
	Total O&M Cost	$MM	$0.61	$0.62	$0.63	$0.64	$0.65	$0.66	$0.67	$0.69	$1.69	$0.71	$0.72	$0.73	$0.75	$0.76	$0.77	$0.78	$1.91	$0.81	$0.82	$0.84	$0.85
	Total O&M Cost	$/MWh		$27.96	$28.43	$28.90	$29.39	$29.88	$30.38	$30.88	$75.92	$31.93	$32.46	$33.01	$33.56	$34.13	$34.70	$35.28	$86.03	$36.48	$37.10	$37.73	$38.37
	RE-CHP																						
w/RE-CHP	Fuel Cost of Power	$/MWh		$18.8	$18.9	$19.0	$19.1	$19.2	$19.3	$19.4	$19.5	$19.6	$19.7	$19.8	$19.9	$20.0	$20.1	$20.2	$20.3	$20.4	$20.5	$20.6	$20.7
w/RE-CHP	Fuel Cost of Thermal Energy	$/$MMBtu_{th}$		$8.2	$8.2	$8.2	$8.3	$8.3	$8.4	$8.4	$8.4	$8.5	$8.5	$8.6	$8.6	$8.7	$8.7	$8.7	$8.8	$8.8	$8.9	$8.9	$9.0
w/RE-CHP	Peak Grid power	MW_e		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
w/RE-CHP	Grid electricity	MWh		5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877
w/RE-CHP	Grid electricity	$MM		$0.45	$0.45	$0.45	$0.46	$0.46	$0.46	$0.46	$0.46	$0.47	$0.47	$0.47	$0.47	$0.48	$0.48	$0.48	$0.48	$0.49	$0.49	$0.49	$0.49
w/RE-CHP	CHP Standby Charges	$MM	10%	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05
w/RE-CHP	**Total cost of Grid power**	$MM		$0.49	$0.50	$0.50	$0.50	$0.50	$0.51	$0.51	$0.51	$0.51	$0.52	$0.52	$0.52	$0.52	$0.53	$0.53	$0.53	$0.53	$0.54	$0.54	$0.54
w/RE-CHP	**Package Boiler Thermal Energy**																						
w/RE-CHP	Thermal Energy delivered	$MMBtu_{th}$		109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140
w/RE-CHP	Natural gas to Boiler	HHV MMBtu		131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494
w/RE-CHP	Natural gas to Boiler	$MM		$0.36	$0.37	$0.37	$0.37	$0.37	$0.37	$0.38	$0.38	$0.38	$0.38	$0.38	$0.39	$0.39	$0.39	$0.39	$0.39	$0.40	$0.40	$0.40	$0.40
w/RE-CHP	TOTAL Fuel Burned (CHP+Blr)	HHV MMBtu		338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587
w/RE-CHP	**CO2 EMISSIONS**																						
	CO2 from grid power	mt CO_2	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718
	CO2 from fuel to boilers	mt CO_2	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815
	CO2 from fuel to CHP	mt CO_2	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583

			2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
	METRICS for RE-CHP																						
w/RE-CHP	Full-Load Optg Hrs	Hrs		8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322	8,322
w/RE-CHP	CHP peak power PEAK	MW_e		**2.86**	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
w/RE-CHP	CHP electricity supplied	MWh	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215	22,215
	Avg. CHP thermal Energy sold	MMBtu/Hr		6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
	Annual CHP thermal Energy sold	MMBtu	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186	51,186
	Avg. Fuel to CHP Engines	HHV MMBtu/Hr	Reconcile	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
	Annual Fuel to CHP Engines	HHV MMBtu	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094	207,094
	RE-CHP: Fraction of Host load supplied																						
	% Electricity from RE-CHP	% from CHP		79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%	79.1%
	% Thermal Energy from RE-CHP	% from CHP		31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%	31.9%
w/RE-CHP	CHP Efficiency	% HHV		61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
w/RE-CHP	CHP Heat Rate	HHV MMBtu/MWh		6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
w/RE-CHP	CHP Thermal Energy Rate	HHV MMBtu/$MMBtu_{th}$		2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
w/RE-CHP	Operations & Maintenance (O&M)																						
	Total O&M Cost	$MM	$0.61	$0.62	$0.63	$0.64	$0.65	$0.66	$0.67	$0.69	$1.69	$0.71	$0.72	$0.73	$0.75	$0.76	$0.77	$0.78	$1.91	$0.81	$0.82	$0.84	$0.85
	Total O&M Cost	$/MWh		$27.96	$28.43	$28.90	$29.39	$29.88	$30.38	$30.88	$75.92	$31.93	$32.46	$33.01	$33.56	$34.13	$34.70	$35.28	$86.03	$36.48	$37.10	$37.73	$38.37
	RE-CHP																						
w/RE-CHP	Fuel Cost of Power	$/MWh		$18.8	$18.9	$19.0	$19.1	$19.2	$19.3	$19.4	$19.5	$19.6	$19.7	$19.8	$19.9	$20.0	$20.1	$20.2	$20.3	$20.4	$20.5	$20.6	$20.7
w/RE-CHP	Fuel Cost of Thermal Energy	$/$MMBtu_{th}$		$8.2	$8.2	$8.2	$8.3	$8.3	$8.4	$8.4	$8.4	$8.5	$8.5	$8.6	$8.6	$8.7	$8.7	$8.7	$8.8	$8.8	$8.9	$8.9	$9.0
w/RE-CHP	Peak Grid power	MW_e		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
w/RE-CHP	Grid electricity	MWh		5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877
w/RE-CHP	Grid electricity	$MM		$0.45	$0.45	$0.45	$0.46	$0.46	$0.46	$0.46	$0.46	$0.47	$0.47	$0.47	$0.47	$0.48	$0.48	$0.48	$0.48	$0.49	$0.49	$0.49	$0.49
w/RE-CHP	CHP Standby Charges	$MM	10%	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05
w/RE-CHP	**Total cost of Grid power**	$MM		$0.49	$0.50	$0.50	$0.50	$0.50	$0.51	$0.51	$0.51	$0.51	$0.52	$0.52	$0.52	$0.52	$0.53	$0.53	$0.53	$0.53	$0.54	$0.54	$0.54
w/RE-CHP	**Package Boiler Thermal Energy**																						
w/RE-CHP	Thermal Energy delivered	$MMBtu_{th}$		109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140	109,140
w/RE-CHP	Natural gas to Boiler	HHV MMBtu		131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494	131,494
w/RE-CHP	Natural gas to Boiler	$MM		$0.36	$0.37	$0.37	$0.37	$0.37	$0.37	$0.38	$0.38	$0.38	$0.38	$0.38	$0.39	$0.39	$0.39	$0.39	$0.39	$0.40	$0.40	$0.40	$0.40
w/RE-CHP	TOTAL Fuel Burned (CHP+Blr)	HHV MMBtu		338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587	338,587
w/RE-CHP	**CO2 EMISSIONS**																						
	CO2 from grid power	mt CO_2	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718	3,718
	CO2 from fuel to boilers	mt CO_2	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815
	CO2 from fuel to CHP	mt CO_2	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583	11,583

	w/RE-CHP: Total CO2 emissions	mt CO_2	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**	**22,116**

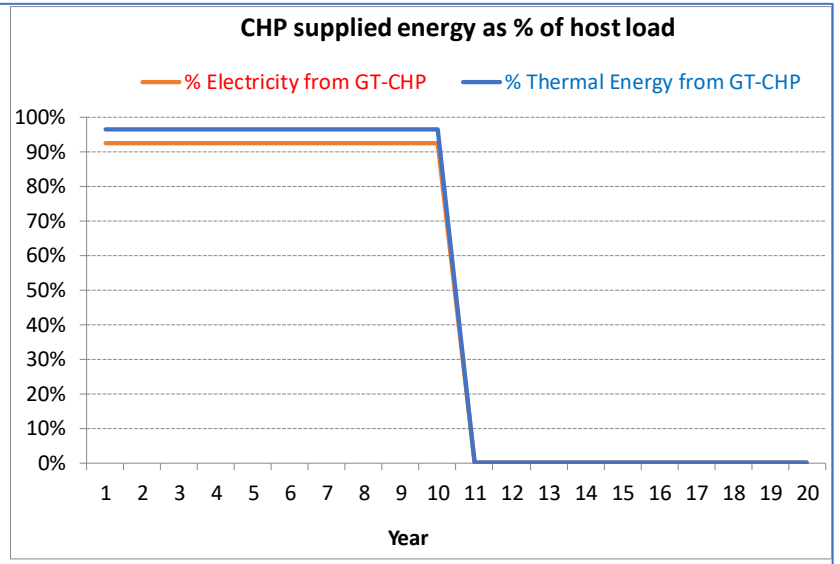
	FINANCIALS		**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
	BASE CASE: NO CHP	Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
No CHP	Cost of Grid Power	$MM		$2.15	$2.16	$2.17	$2.18	$2.19	$2.20	$2.21	$2.22	$2.23	$2.24	$2.26	$2.27	$2.28	$2.29	$2.30	$2.31	$2.32	$2.34	$2.35	$2.36
No CHP	Cost of Blr natural gas	$MM		$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6
No CHP	Cost of Blr O&M	$MM		$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3
No CHP	**Total non-CHP Energy Cost**	**$MM**		**$3.0**	**$3.1**	**$3.1**	**$3.1**	**$3.1**	**$3.1**	**$3.1**	**$3.1**	**$3.2**	**$3.2**	**$3.2**	**$3.2**	**$3.2**	**$3.2**	**$3.3**	**$3.3**	**$3.3**	**$3.3**	**$3.3**	**$3.4**
	RE-CHP																						
w/RE-CHP	Cost of Grid Power	$MM		$0.4	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5
w/RE-CHP	Grid power Standby Charges	$MM		$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
w/RE-CHP	Total cost of Grid power	**$MM**		**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**
w/RE-CHP	Cost of Blr natural gas	$MM		$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4
w/RE-CHP	Cost of RE natural gas	$MM		$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7
w/RE-CHP	Fuel Total: natural gas	**$MM**		**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.0**	**$1.1**	**$1.1**	**$1.1**	**$1.1**	**$1.1**	**$1.1**	**$1.1**	**$1.1**	**$1.1**
w/RE-CHP	O&M: Boilers	$MM		$0.138	$0.139	$0.141	$0.142	$0.143	$0.145	$0.146	$0.148	$0.149	$0.151	$0.152	$0.154	$0.155	$0.157	$0.158	$0.160	$0.162	$0.163	$0.165	$0.166
w/RE-CHP	O&M: RE-CHP	$MM		$0.6	$0.6	$0.6	$0.7	$0.7	$0.7	$0.7	$1.7	$0.7	$0.7	$0.7	$0.7	$0.8	$0.8	$0.8	$1.9	$0.8	$0.8	$0.8	$0.9
w/RE-CHP	O&M. Total	**$MM**		**$0.8**	**$0.8**	**$0.8**	**$0.8**	**$0.8**	**$0.8**	**$0.8**	**$1.8**	**$0.9**	**$0.9**	**$0.9**	**$0.9**	**$0.9**	**$0.9**	**$0.9**	**$2.1**	**$1.0**	**$1.0**	**$1.0**	**$1.0**
	Total RE-CHP Fuel+OpEx Cost	**$MM**		**$2.2**	**$2.3**	**$2.3**	**$2.3**	**$2.3**	**$2.3**	**$2.4**	**$3.4**	**$2.4**	**$2.4**	**$2.5**	**$2.5**	**$2.5**	**$2.5**	**$2.5**	**$3.7**	**$2.6**	**$2.6**	**$2.6**	**$2.7**
	RE-CHP Debt Service																						
	Principal	$MM		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Interest	$MM		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Total Payment	**$MM**		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
	Total RE-CHP Cost (Fuel+OpEx+Debt Service)	**$MM**		**$2.2**	**$2.3**	**$2.3**	**$2.3**	**$2.3**	**$2.3**	**$2.4**	**$3.4**	**$2.4**	**$2.4**	**$2.5**	**$2.5**	**$2.5**	**$2.5**	**$2.5**	**$3.7**	**$2.6**	**$2.6**	**$2.6**	**$2.7**
	Savings: RE-CHP Vs. No CHP	**$MM**		**$0.8**	**$0.8**	**$0.8**	**$0.8**	**$0.8**	**$0.8**	**$0.8**	**($0.2)**	**$0.8**	**$0.8**	**$0.7**	**$0.7**	**$0.7**	**$0.7**	**$0.7**	**($0.4)**	**$0.7**	**$0.7**	**$0.7**	**$0.7**
	CUMULATIVE Savings: RE-CHP Vs. No CHP	**$MM**		$0.8	$1.6	$2.4	$3.1	$3.9	$4.7	$5.4	$5.2	$6.0	$6.7	$7.5	$8.2	$8.9	$9.7	$10.4	$10.0	$10.7	$11.4	$12.1	$12.8
	Multiple of Investment on Equity			0.13	0.27	0.40	0.53	0.67	0.80	0.93	0.89	1.02	1.15	1.27	1.40	1.53	1.65	1.77	1.71	1.83	1.95	2.07	2.19

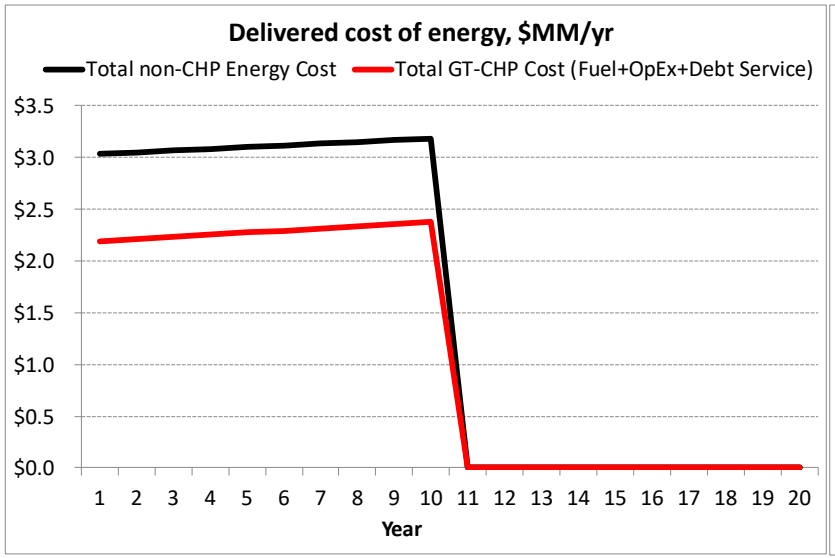
CHP BASE CASE: 2 x OPRA GT

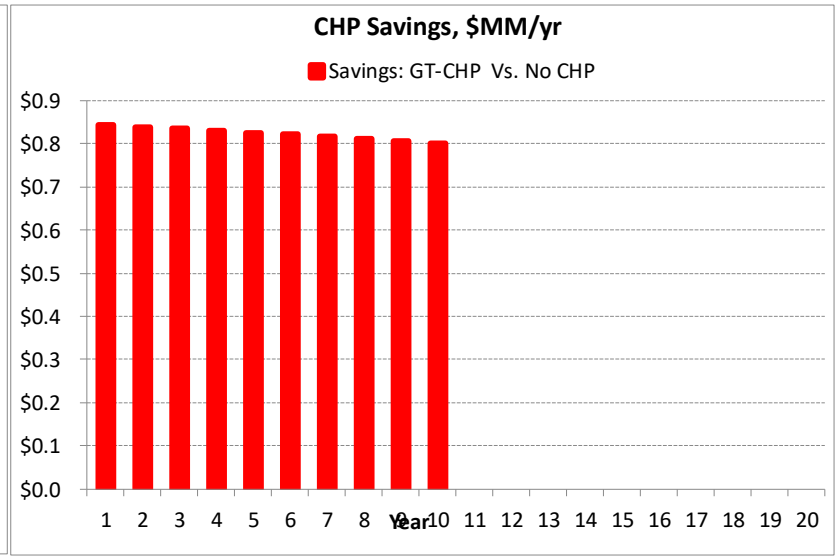
Good electrical fit, average thermal fit; economics hurt by high CapEx and OpEx. Lower thermal utilization

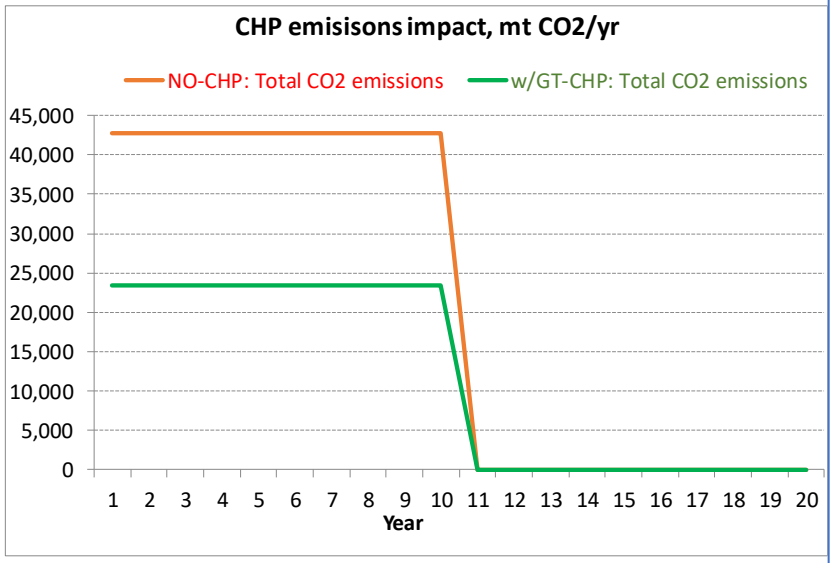
INPUT	UNIT	VALUE	COMMENT
Natural Gas at "Burner tip"	$/MMBtu, HHV	**$2.76**	assumed
All-in Grid power price	c/KWh	**7.6**	assumed
CHP full-load availability	%	**97%**	assumed
W/CHP, Grid Standby Charges	% of value of CHP pwr	**10%**	assumed
OPRA Gas Turbine (GT) CHP			OPRA16
Project term	years	**10**	
GT-CHP Project Investment	$/KW$_e$	$2,828	CapEx estimate
# of GT-CHP systems		2	as configured
Iso Power	KW$_e$	1,750	3500 KWe CHP capacit
CHP project financing			
Equity:Debt Ratio	%	**100%**	assumed
Debt Term	years	**12**	assumed
Cost of Debt	%	**7%**	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	**83%**	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	**125**	typical

	OUTPUT	UNIT	VALUE No CHP	VALUE GT-CHP	Difference
Project Financing Structure					
100%	Equity	$MM	-	$9.9	
0%	Debt	$MM	-	$0.0	
100%	**CHP only Investment incl. 10% ITC**	**$MM**	-	**$9.9**	
Site Energy Expense in Year 1					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$3.0	$2.2	**$0.8**
Site Energy Expense over Project term 10 years					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$31.1	$22.9	$8.2
	Multiple of Investment on Equity		-	**0.8**	
HHV Thermodynamic Metrics					
	Efficiency	%	-	60%	
	Electrical Heat Rate	MMBtu/MWh	-	8.9	
	Thermal Energy Rate	MMBtu/MMBtu$_{th}$	-	1.5	
	CHP Thermal Utilization	%	-	64%	







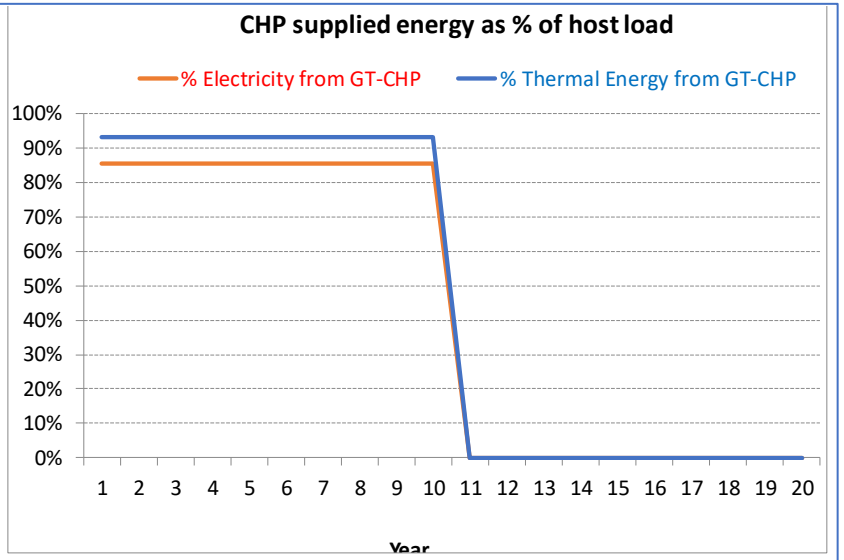


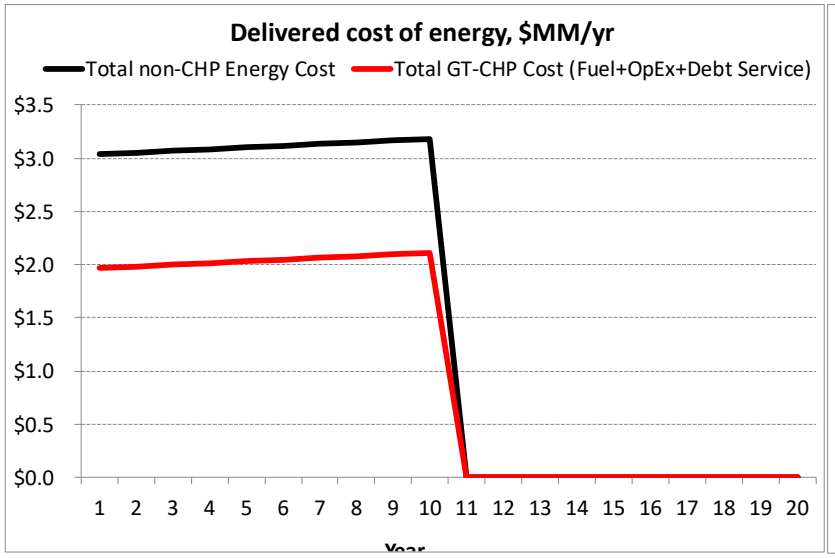
CHP BASE CASE: 1 x Centaur 40 GT

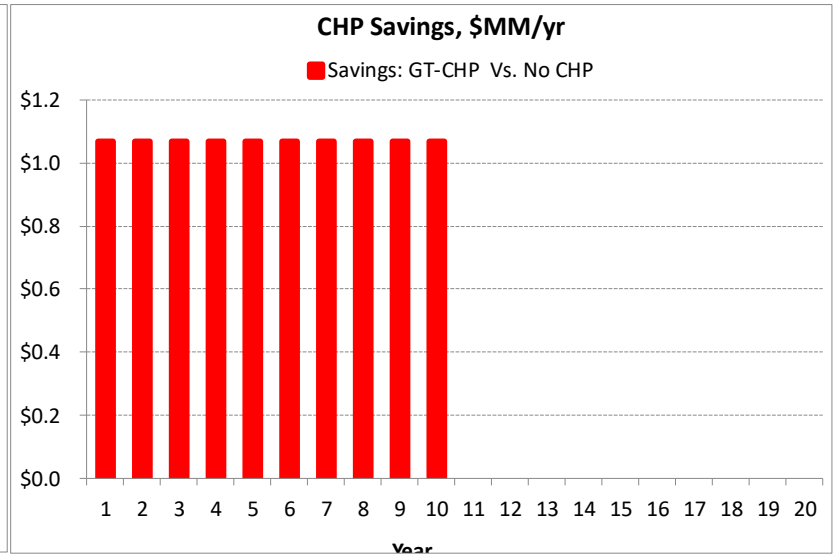
Good technical fit; economics hurt by high CapEx and assumed high grid standby charge. Higher thermal utilization

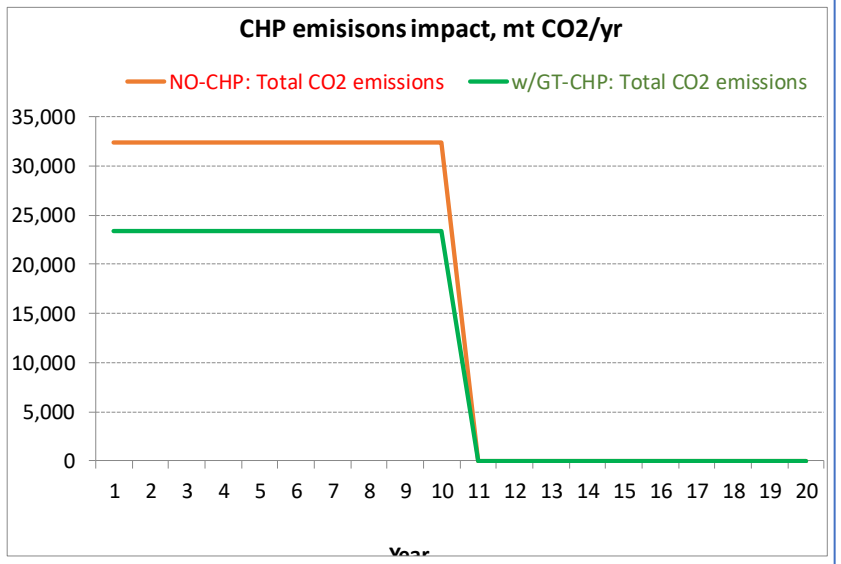
INPUT		UNIT	VALUE	COMMENT
Natural Gas at "Burner tip"		$/MMBtu, HHV	**$2.76**	assumed
All-in Grid power price		c/KWh	**7.6**	assumed
CHP full-load availability		%	**95%**	assumed
W/CHP, Grid Standby Charges		% of value of CHP pwr	**20%**	assumed
OPRA Gas Turbine (GT) CHP				Centaur40
Project term		years	**10**	
GT-CHP Project Investment		$/KW$_e$	$2,918	CapEx estimate
# of GT-CHP systems			1	as configured
Iso Power		KW$_e$	3,159	3159 KWe CHP capacit
CHP project financing				
Equity:Debt Ratio		%	**100%**	assumed
Debt Term		years	**12**	assumed
Cost of Debt		%	**7%**	assumed
Pre-CHP Package Boiler				
Displaced package boiler efficiency		% HHV	**83%**	site data
Package Boiler: Variable Charge/cost		cents/MMBtu$_{th}$	**125**	typical

	OUTPUT	UNIT	VALUE No CHP	VALUE GT-CHP	Difference
Project Financing Structure					
100%	Equity	$MM	-	$9.2	
0%	Debt	$MM	-	$0.0	
100%	**CHP only Investment incl. 10% ITC**	**$MM**	-	**$9.2**	
Site Energy Expense in Year 1					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$3.0	$2.0	**$1.1**
Site Energy Expense over Project term 10 years					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$31.1	$20.4	$10.7
	Multiple of Investment on Equity		-	**1.2**	
HHV Thermodynamic Metrics					
	Efficiency	%	-	63%	
	Electrical Heat Rate	MMBtu/MWh	-	8.3	
	Thermal Energy Rate	MMBtu/MMBtu$_{th}$	-	1.3	
	CHP Thermal Utilization	%	-	77%	







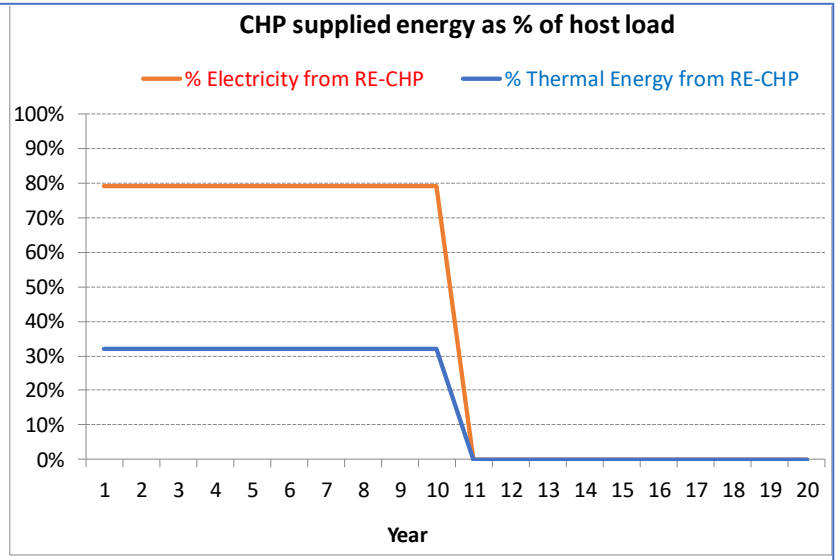


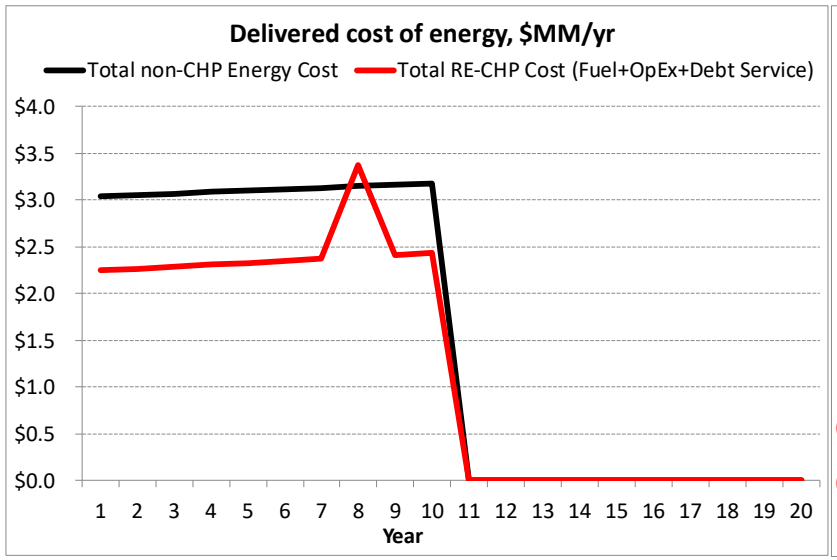
CHP BASE CASE: 2 x JMS420 RE

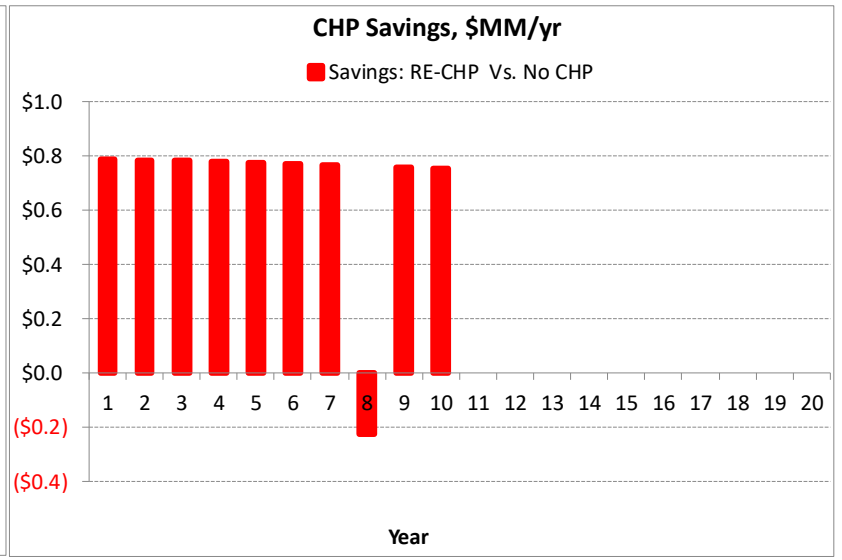
Good electrical fit; average thermal fit. Economics helped by low CapEx but hurt by high OpEx including 60,000 major overhauls ("spiky"). CHP efficiency low due to wasted low-grade thermal energy (hot water). Lower thermal utilization

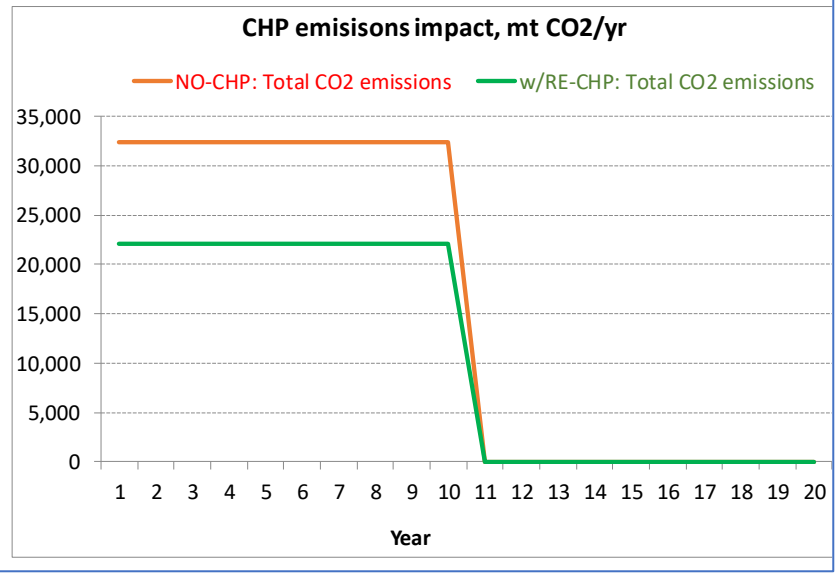
INPUT	UNIT	VALUE	COMMENT
Natural Gas at "Burner tip"	$/MMBtu, HHV	**$2.76**	assumed
All-in Grid power price	c/KWh	**7.6**	assumed
CHP full-load availability	%	**95%**	assumed
W/CHP, Grid Standby Charges	% of value of CHP pwr	**10%**	assumed
Reciprocating Internal Combustion Engine (RE) CHP			JMS420
Project term	years	**10**	
RE-CHP Project Investment	$/KW$_e$	$2,051	CapEx estimate
# of RE-CHP systems		2	as configured
Iso Power	KW$_e$	1,429	2858 KWe CHP capacit
CHP project financing			
Equity:Debt Ratio	%	**100%**	assumed
Debt Term	years	**12**	assumed
Cost of Debt	%	**7%**	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	**83%**	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	**125**	typical

	OUTPUT	UNIT	VALUE No CHP	VALUE RE-CHP	Difference
Project Financing Structure					
100%	Equity	$MM	-	$5.9	
0%	Debt	$MM	-	$0.0	
100%	**CHP only Investment incl. 10% ITC**	**$MM**	-	**$5.9**	
Site Energy Expense in Year 1					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$3.0	$2.2	**$0.8**
Site Energy Expense over Project term 10 years					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$31.1	$24.4	$6.7
	Multiple of Investment on Equity		-	**1.1**	
HHV Thermodynamic Metrics					
	Efficiency	%	-	61%	
	Electrical Heat Rate	MMBtu/MWh	-	6.8	
	Thermal Energy Rate	MMBtu/MMBtu$_{th}$	-	2.9	
	CHP Thermal Utilization	%	-	63%	









Alternate scenario: Base Case (100% equity) and CHP project horizon 15-years & 20-years

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	50%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	7.6	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	15	
Equity:Debt Ratio	%	100%	assumed
Debt Term	years	10	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/$MMBtu_{th}$	125	assumed

		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/$KW_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$5.9	$9.9	$9.2
****Equity-Multiple of Investment (MOI)**		**-**	**1.8**	**1.2**	**1.7**
*****Site Energy Expense**					
Year 1	$MM	$3.0	$2.2	$2.2	$2.0
Year 15	$MM	$47	$37	$35	$31
Cum. %redn. 15 yrs	% reduction	0%	-22%	-26%	-34%
Emissions					
From grid power	mt CO_2	22,184	4,641	1,652	3,246
From fuel to Blrs	mt CO_2	10,264	6,987	360	699
From fuel to CHP	mt CO_2	-	11,004	21,434	19,395
TOTAL site emissions	**mt CO_2**	**32,448**	**22,633**	**23,446**	**23,340**
Emissions reduction	% change	0%	-30%	-28%	-28%
CHP technical					
CHP capacity	KW_e	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	61.3%	60.4%	63.4%
Thermal Utilization	%		63%	64%	77%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	193,164	131,494	6,769	13,161
Fuel to CHP	MMBtu	-	207,094	403,375	365,005
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**193,164**	**338,587**	**410,144**	**378,166**
Elec. From grid	MWh	28,093	5,877	2,093	4,110
Elec. From CHP	MWh	-	22,215	26,000	23,982
TOTAL Elec. (CHP + grid)	**MWh**	**28,093**	**28,093**	**28,093**	**28,093**

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	50%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	7.6	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	20	
Equity:Debt Ratio	%	100%	assumed
Debt Term	years	10	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/$MMBtu_{th}$	125	assumed

		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/$KW_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$5.9	$9.9	$9.2
****Equity-Multiple of Investment (MOI)**		**-**	**2.2**	**1.6**	**2.3**
*****Site Energy Expense**					
Year 1	$MM	$3.0	$2.2	$2.2	$2.0
Year 20	$MM	$64	$51	$48	$42
Cum. %redn. 20 yrs	% reduction	0%	-20%	-25%	-33%
Emissions					
From grid power	mt CO_2	22,184	4,641	1,652	3,246
From fuel to Blrs	mt CO_2	10,264	6,987	360	699
From fuel to CHP	mt CO_2	-	11,004	21,434	19,395
TOTAL site emissions	**mt CO_2**	**32,448**	**22,633**	**23,446**	**23,340**
Emissions reduction	% change	0%	-30%	-28%	-28%
CHP technical					
CHP capacity	KW_e	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	61.3%	60.4%	63.4%
Thermal Utilization	%		63%	64%	77%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	193,164	131,494	6,769	13,161
Fuel to CHP	MMBtu	-	207,094	403,375	365,005
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**193,164**	**338,587**	**410,144**	**378,166**
Elec. From grid	MWh	28,093	5,877	2,093	4,110
Elec. From CHP	MWh	-	22,215	26,000	23,982
TOTAL Elec. (CHP + grid)	**MWh**	**28,093**	**28,093**	**28,093**	**28,093**

Alternate scenario: base case (100% equity) with 25% and 75% future site load increases

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	25%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	7.6	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	10	
Equity:Debt Ratio	%	100%	assumed
Debt Term	years	10	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	125	assumed

		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/KW$_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$5.9	$9.9	$9.2
****Equity-Multiple of Investment (MOI)**		**-**	**1.0**	**0.6**	**1.0**
***Site Energy Expense**					
Year 1	$MM	$2.5	$1.8	$1.9	$1.7
Year 10	$MM	$26	$20	$20	$17
Cum. %redn. 10 yrs	% reduction	0%	-23%	-22%	-34%
Emissions					
From grid power	mt CO_2	18,487	1,891	632	1,285
From fuel to Blrs	mt CO_2	8,553	5,576	280	537
From fuel to CHP	mt CO_2	-	10,445	19,093	18,053
TOTAL site emissions	**mt CO_2**	**27,040**	**17,912**	**20,005**	**19,875**
Emissions reduction	% change	0%	-34%	-26%	-26%
CHP technical					
CHP capacity	KW$_e$	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	60.2%	57.4%	58.7%
Thermal Utilization	%		61%	61%	71%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	160,970	104,937	5,264	10,108
Fuel to CHP	MMBtu	-	196,563	359,330	339,751
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**160,970**	**301,500**	**364,594**	**349,859**
Elec. From grid	MWh	23,411	2,395	801	1,627
Elec. From CHP	MWh	-	21,016	22,610	21,783
TOTAL Elec. (CHP + grid)	**MWh**	**23,411**	**23,411**	**23,411**	**23,411**

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	75%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	7.6	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	10	
Equity:Debt Ratio	%	100%	assumed
Debt Term	years	10	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	125	assumed

		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/KW$_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$5.9	$9.9	$9.2
****Equity-Multiple of Investment (MOI)**		**-**	**1.2**	**1.0**	**1.2**
***Site Energy Expense**					
Year 1	$MM	$3.5	$2.7	$2.5	$2.4
Year 10	$MM	$36	$29	$26	$25
Cum. %redn. 10 yrs	% reduction	0%	-19%	-27%	-32%
Emissions					
From grid power	mt CO_2	25,882	7,961	4,161	6,320
From fuel to Blrs	mt CO_2	11,975	8,483	441	1,194
From fuel to CHP	mt CO_2	-	11,224	22,522	19,870
TOTAL site emissions	**mt CO_2**	**37,856**	**27,668**	**27,124**	**27,384**
Emissions reduction	% change	0%	-27%	-28%	-28%
CHP technical					
CHP capacity	KW$_e$	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	62.5%	64.7%	67.6%
Thermal Utilization	%		66%	70%	85%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	225,358	159,644	8,296	22,472
Fuel to CHP	MMBtu	-	211,233	423,852	373,952
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**225,358**	**370,877**	**432,149**	**396,424**
Elec. From grid	MWh	32,775	10,081	5,269	8,003
Elec. From CHP	MWh	-	22,693	27,506	24,772
TOTAL Elec. (CHP + grid)	**MWh**	**32,775**	**32,775**	**32,775**	**32,775**

Alternate scenario: financial leverage (25% equity) boosts MOI. CHP: 10-years and 20-years

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	50%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	7.6	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	10	
Equity:Debt Ratio	%	25%	assumed
Debt Term	years	7	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	125	assumed

		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/KW$_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$1.5	$2.5	$2.3
****Equity-Multiple of Investment (MOI)**		**-**	**0.7**	**(0.6)**	**0.7**
*****Site Energy Expense**					
Year 1	$MM	$3.0	$3.1	$3.6	$3.3
Year 10	$MM	$31	$30	$32	$29
Cum. %redn. 10 yrs	% reduction	0%	-3%	5%	-6%
Emissions					
From grid power	mt CO_2	22,184	4,641	1,652	3,246
From fuel to Blrs	mt CO_2	10,264	6,987	360	699
From fuel to CHP	mt CO_2	-	11,004	21,434	19,395
TOTAL site emissions	**mt CO_2**	**32,448**	**22,633**	**23,446**	**23,340**
Emissions reduction	% change	0%	-30%	-28%	-28%
CHP technical					
CHP capacity	KW$_e$	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	61.3%	60.4%	63.4%
Thermal Utilization	%		63%	64%	77%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	193,164	131,494	6,769	13,161
Fuel to CHP	MMBtu	-	207,094	403,375	365,005
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**193,164**	**338,587**	**410,144**	**378,166**
Elec. From grid	MWh	28,093	5,877	2,093	4,110
Elec. From CHP	MWh	-	22,215	26,000	23,982
TOTAL Elec. (CHP + grid)	**MWh**	**28,093**	**28,093**	**28,093**	**28,093**

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	50%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	7.6	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	20	
Equity:Debt Ratio	%	25%	assumed
Debt Term	years	7	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	125	assumed

			NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover			-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/KW$_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$1.5	$2.5	$2.3
****Equity-Multiple of Investment (MOI)**		**-**	**4.8**	**2.5**	**5.4**
*****Site Energy Expense**					
Year 1	$MM	$3.0	$3.1	$3.6	$3.3
Year 20	$MM	$64	$57	$58	$51
Cum. %redn. 20 yrs	% reduction	0%	-11%	-10%	-19%
Emissions					
From grid power	mt CO_2	22,184	4,641	1,652	3,246
From fuel to Blrs	mt CO_2	10,264	6,987	360	699
From fuel to CHP	mt CO_2	-	11,004	21,434	19,395
TOTAL site emissions	**mt CO_2**	**32,448**	**22,633**	**23,446**	**23,340**
Emissions reduction	% change	0%	-30%	-28%	-28%
CHP technical					
CHP capacity	KW$_e$	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	61.3%	60.4%	63.4%
Thermal Utilization	%		63%	64%	77%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	193,164	131,494	6,769	13,161
Fuel to CHP	MMBtu	-	207,094	403,375	365,005
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**193,164**	**338,587**	**410,144**	**378,166**
Elec. From grid	MWh	28,093	5,877	2,093	4,110
Elec. From CHP	MWh	-	22,215	26,000	23,982
TOTAL Elec. (CHP + grid)	**MWh**	**28,093**	**28,093**	**28,093**	**28,093**

Other scenarios? Eg: higher grid price increases MOI; leverage & CHP years *turbocharge* MOI.

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	50%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	10.0	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	10	
Equity:Debt Ratio	%	100%	assumed
Debt Term	years	7	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/$MMBtu_{th}$	125	assumed

		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/$KW_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$5.9	$9.9	$9.2
****Equity-Multiple of Investment (MOI)**		**-**	**2.1**	**1.5**	**1.8**
*****Site Energy Expense**					
Year 1	$MM	$3.7	$2.4	$2.2	$2.1
Year 10	$MM	$38	$26	$23	$22
Cum. %redn. 10 yrs	% reduction	0%	-32%	-38%	-43%
Emissions					
From grid power	mt CO_2	22,184	4,641	1,652	3,246
From fuel to Blrs	mt CO_2	10,264	6,987	360	699
From fuel to CHP	mt CO_2	-	11,004	21,434	19,395
TOTAL site emissions	**mt CO_2**	**32,448**	**22,633**	**23,446**	**23,340**
Emissions reduction	% change	0%	-30%	-28%	-28%
CHP technical					
CHP capacity	KW_e	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	61.3%	60.4%	63.4%
Thermal Utilization	%		63%	64%	77%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	193,164	131,494	6,769	13,161
Fuel to CHP	MMBtu	-	207,094	403,375	365,005
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**193,164**	**338,587**	**410,144**	**378,166**
Elec. From grid	MWh	28,093	5,877	2,093	4,110
Elec. From CHP	MWh	-	22,215	26,000	23,982
TOTAL Elec. (CHP + grid)	**MWh**	**28,093**	**28,093**	**28,093**	**28,093**

COMMON INPUT's	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	50%	2020 base
Natural Gas at "Burner tip"	$/MMBtu, HHV	$2.76	site data
All-in Grid power price	c/KWh	10.0	site data
CHP project financing			
CHP Project horizon (max 20-yrs)	years	20	
Equity:Debt Ratio	%	25%	assumed
Debt Term	years	7	assumed
Cost of Debt	%	7%	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	83%	site data
Package Boiler: Variable Charge/cost	cents/$MMBtu_{th}$	125	assumed

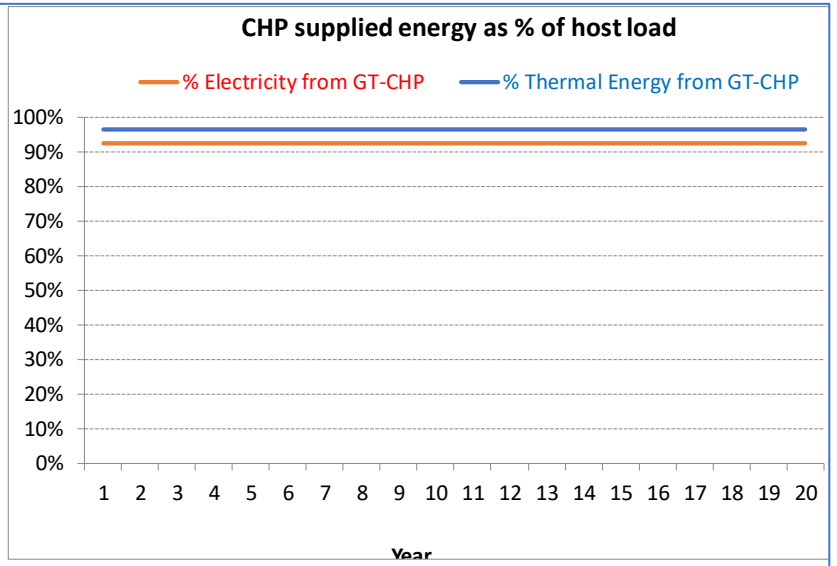
		NO CHP	*Recip. Engine*	*Gas Turbine*	*Gas Turbine*
CHP Prime Mover		-	JMS420	OPRA16	Centaur40
CHP Configuration		**Grid + Blrs only**	**2 x JMS420**	**2 x OPRA16**	**1 x Centaur40**
***Pjt. Inv. w/10% ITC**	$MM	-	**$5.9**	**$9.9**	**$9.2**
	$/$KW_e$	-	$2,051	$2,828	$2,918
of which Equity reqd.	$MM	-	$1.5	$2.5	$2.3
****Equity-Multiple of Investment (MOI)**		**-**	**12.3**	**7.8**	**10.5**
*****Site Energy Expense**					
Year 1	$MM	$3.7	$3.2	$3.6	$3.4
Year 20	$MM	$78	$60	$59	$54
Cum. %redn. 20 yrs	% reduction	0%	-23%	-25%	-31%
Emissions					
From grid power	mt CO_2	22,184	4,641	1,652	3,246
From fuel to Blrs	mt CO_2	10,264	6,987	360	699
From fuel to CHP	mt CO_2	-	11,004	21,434	19,395
TOTAL site emissions	**mt CO_2**	**32,448**	**22,633**	**23,446**	**23,340**
Emissions reduction	% change	0%	-30%	-28%	-28%
CHP technical					
CHP capacity	KW_e	-	2,858	3,500	3,159
CHP efficiency	% HHV	-	61.3%	60.4%	63.4%
Thermal Utilization	%		63%	64%	77%
Annual Energy supply to site					
Fuel to Blrs	MMBtu	193,164	131,494	6,769	13,161
Fuel to CHP	MMBtu	-	207,094	403,375	365,005
TOTAL Fuel (CHP + Blrs)	**MMBtu**	**193,164**	**338,587**	**410,144**	**378,166**
Elec. From grid	MWh	28,093	5,877	2,093	4,110
Elec. From CHP	MWh	-	22,215	26,000	23,982
TOTAL Elec. (CHP + grid)	**MWh**	**28,093**	**28,093**	**28,093**	**28,093**

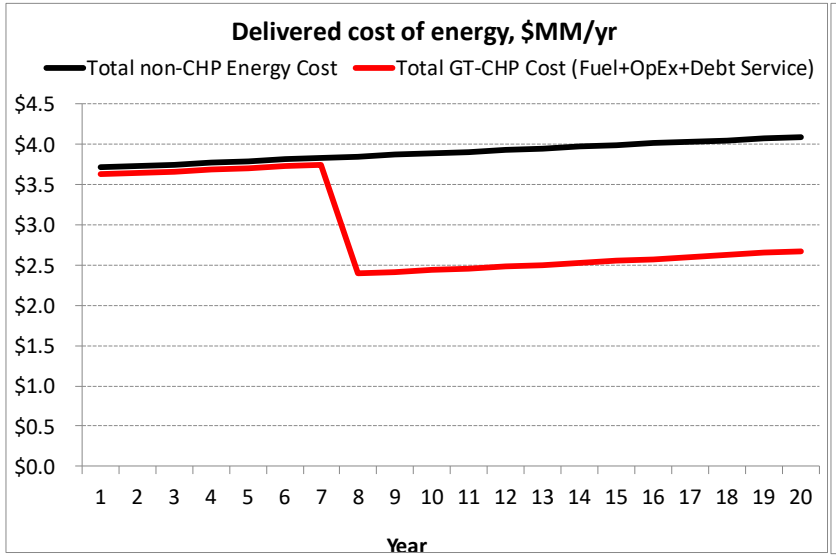
2 x OPRA GT ideal upside: leverage (25% equity), high grid power (10 cents/KWh) and CHP 20-years

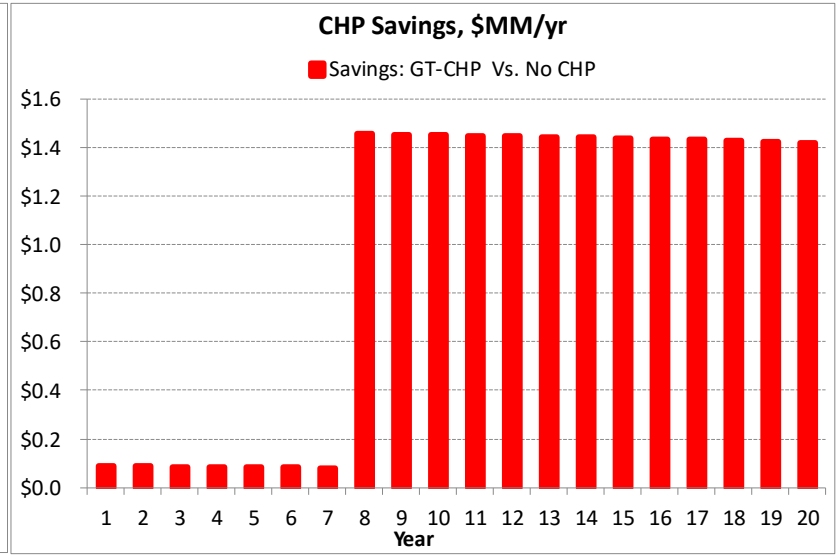
Good electrical fit, average thermal fit; economics hurt by high CapEx and OpEx. Lower thermal utilization

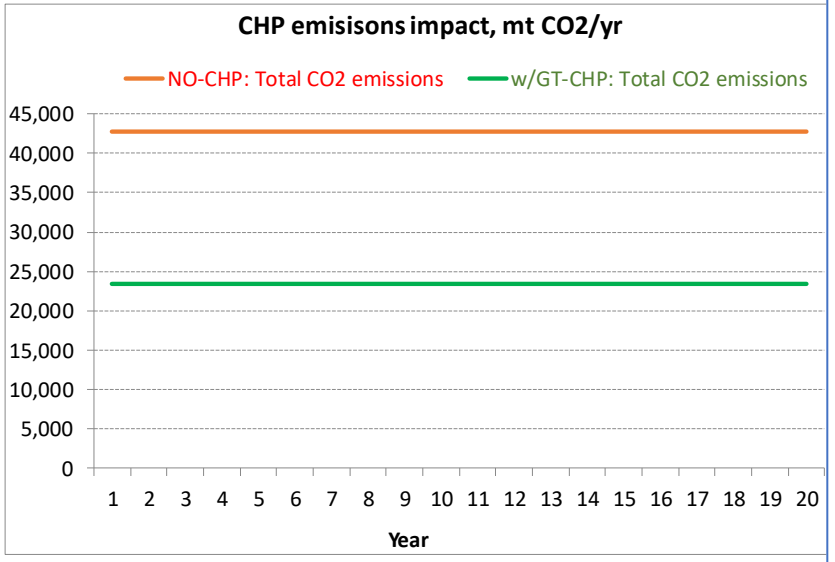
INPUT	UNIT	VALUE	COMMENT
Natural Gas at "Burner tip"	$/MMBtu, HHV	**$2.76**	assumed
All-in Grid power price	c/KWh	**10.0**	assumed
CHP full-load availability	%	**97%**	assumed
W/CHP, Grid Standby Charges	% of value of CHP pwr	**10%**	assumed
OPRA Gas Turbine (GT) CHP			OPRA16
Project term	years	**20**	
GT-CHP Project Investment	$/KW$_e$	$2,828	CapEx estimate
# of GT-CHP systems		2	as configured
Iso Power	KW$_e$	1,750	3500 KWe CHP capacit
CHP project financing			
Equity:Debt Ratio	%	**25%**	assumed
Debt Term	years	**7**	assumed
Cost of Debt	%	**7%**	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	**83%**	site data
Package Boiler: Variable Charge/cost	cents/MMBtu$_{th}$	**125**	typical

	OUTPUT	UNIT	VALUE No CHP	VALUE GT-CHP	Difference
Project Financing Structure					
25%	Equity	$MM	-	$2.5	
75%	Debt	$MM	-	$7.4	
100%	**CHP only Investment incl. 10% ITC**	**$MM**	-	**$9.9**	
Site Energy Expense in Year 1					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$3.7	$3.6	**$0.1**
Site Energy Expense over Project term 20 years					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$78.0	$58.7	$19.3
	Multiple of Investment on Equity		-	**7.8**	
HHV Thermodynamic Metrics					
	Efficiency	%	-	60%	
	Electrical Heat Rate	MMBtu/MWh	-	8.9	
	Thermal Energy Rate	MMBtu/MMBtu$_{th}$	-	1.5	
	CHP Thermal Utilization	%	-	64%	







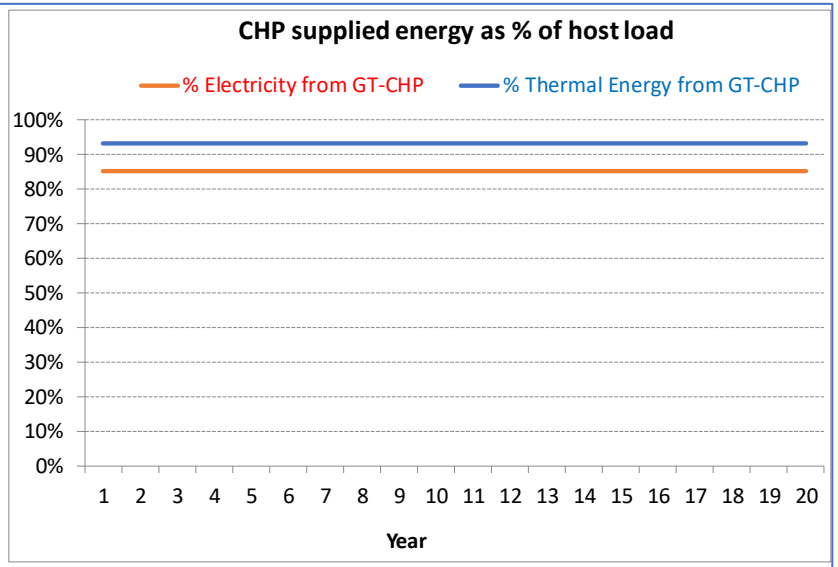


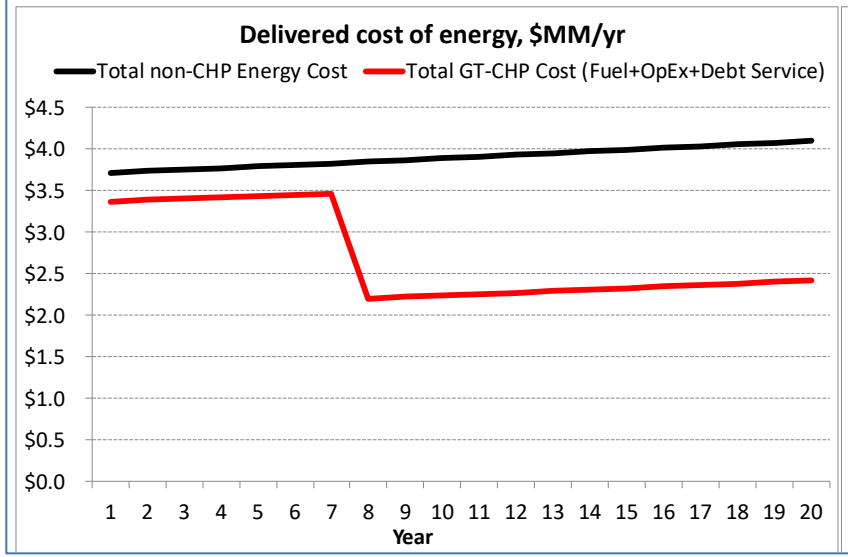
1 x Centaur40 GT ideal upside: leverage (25% equity), high grid power (10 cents/KWh) and CHP 20-years

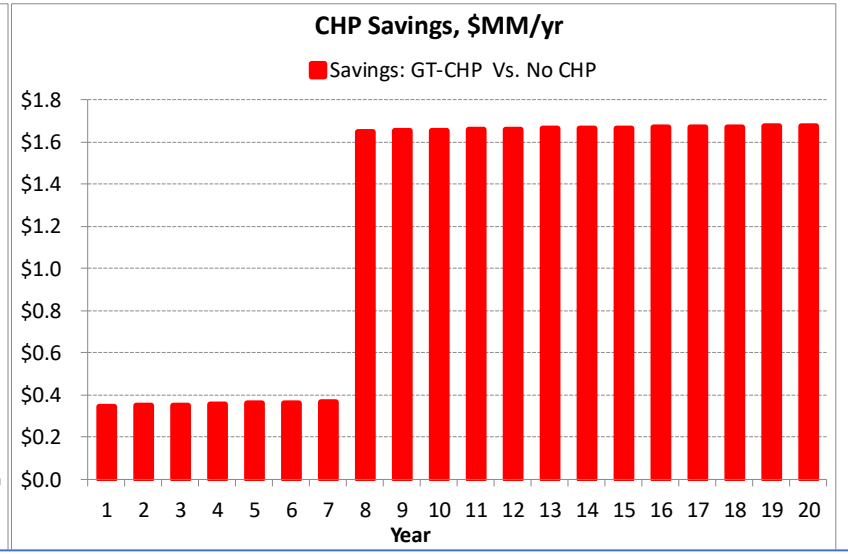
Good technical fit; economics hurt by high CapEx and assumed high grid standby charge. Higher thermal utilization

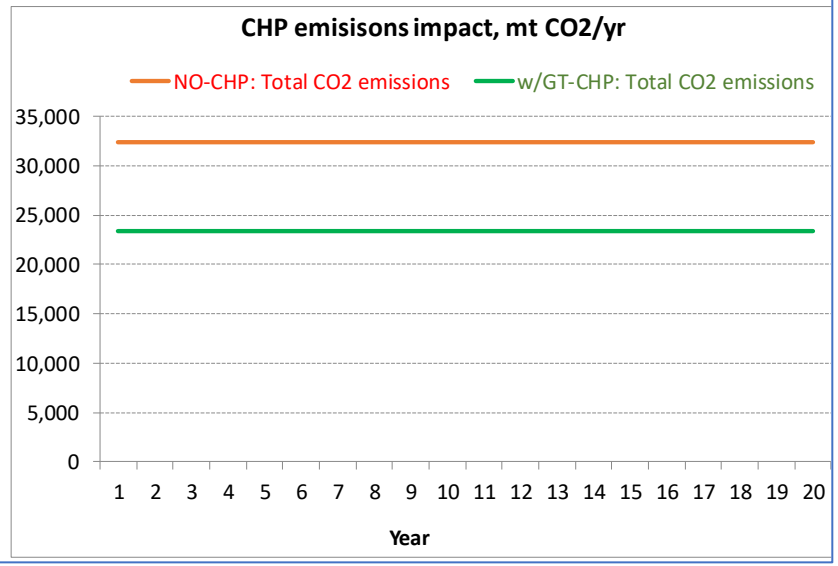
INPUT	UNIT	VALUE	COMMENT
Natural Gas at "Burner tip"	$/MMBtu, HHV	**$2.76**	assumed
All-in Grid power price	c/KWh	**10.0**	assumed
CHP full-load availability	%	**95%**	assumed
W/CHP, Grid Standby Charges	% of value of CHP pwr	**20%**	assumed
OPRA Gas Turbine (GT) CHP			Centaur40
Project term	years	**20**	
GT-CHP Project Investment	$/$KW_e$	$2,918	CapEx estimate
# of GT-CHP systems		1	as configured
Iso Power	KW_e	3,159	3159 KWe CHP capacit
CHP project financing			
Equity:Debt Ratio	%	**25%**	assumed
Debt Term	years	**7**	assumed
Cost of Debt	%	**7%**	assumed
Pre-CHP Package Boiler			
Displaced package boiler efficiency	% HHV	**83%**	site data
Package Boiler: Variable Charge/cost	cents/$MMBtu_{th}$	**125**	typical

	OUTPUT	UNIT	VALUE No CHP	VALUE GT-CHP	Difference
Project Financing Structure					
25%	Equity	$MM	-	$2.3	
75%	Debt	$MM	-	$6.9	
100%	**CHP only Investment incl. 10% ITC**	**$MM**	-	**$9.2**	
Site Energy Expense in Year 1					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$3.7	$3.4	**$0.3**
Site Energy Expense over Project term 20 years					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$78.0	$54.0	$24.1
	Multiple of Investment on Equity		-	**10.5**	
HHV Thermodynamic Metrics					
	Efficiency	%	-	63%	
	Electrical Heat Rate	MMBtu/MWh	-	8.3	
	Thermal Energy Rate	$MMBtu/MMBtu_{th}$	-	1.3	
	CHP Thermal Utilization	%	-	77%	







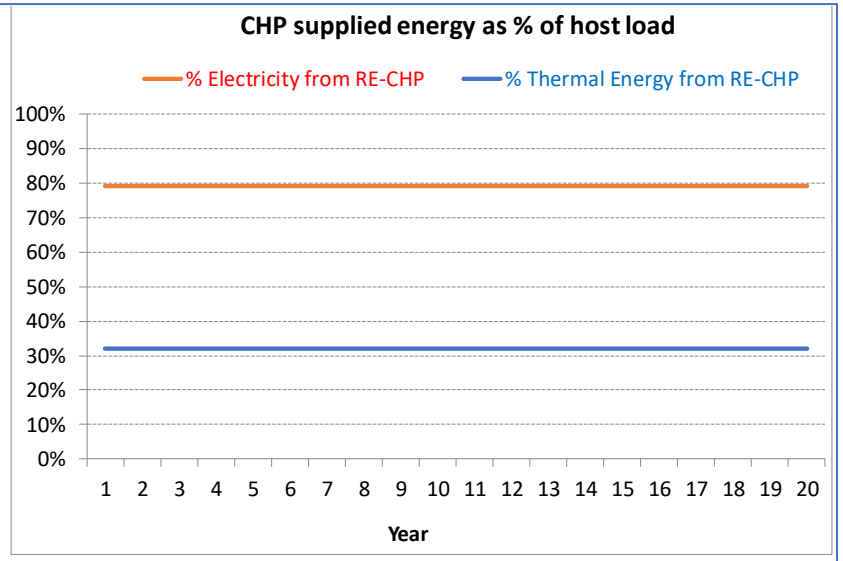


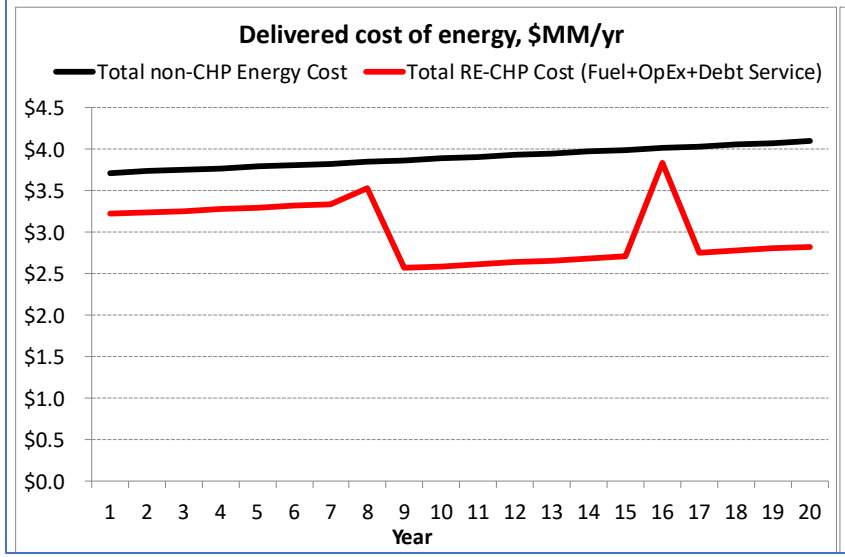
2 x JMS420 RE ideal upside: leverage (25% equity), high grid power (10 cents/KWh) and CHP 20-years

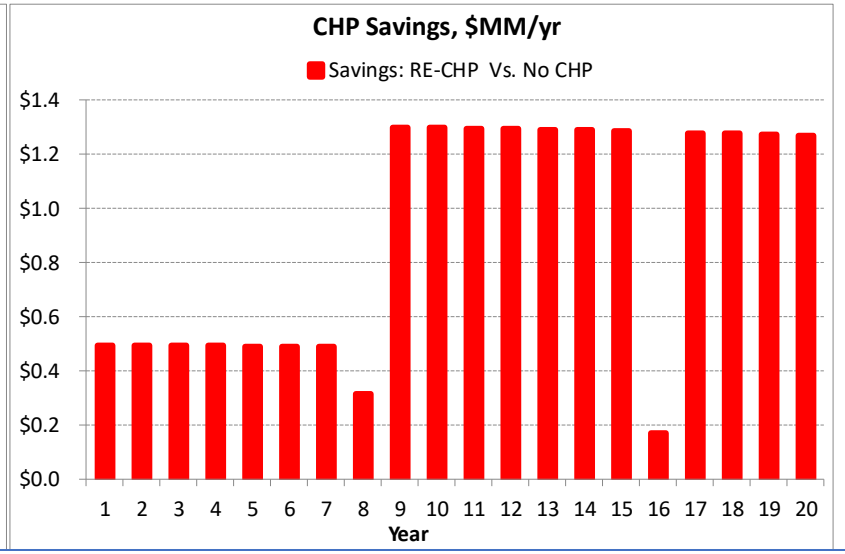
Good electrical fit; average thermal fit. Economics helped by low CapEx but hurt by high OpEx including 60,000 major overhauls ("spiky"). CHP efficiency low due to wasted low-grade thermal energy (hot water). Lower thermal utilization

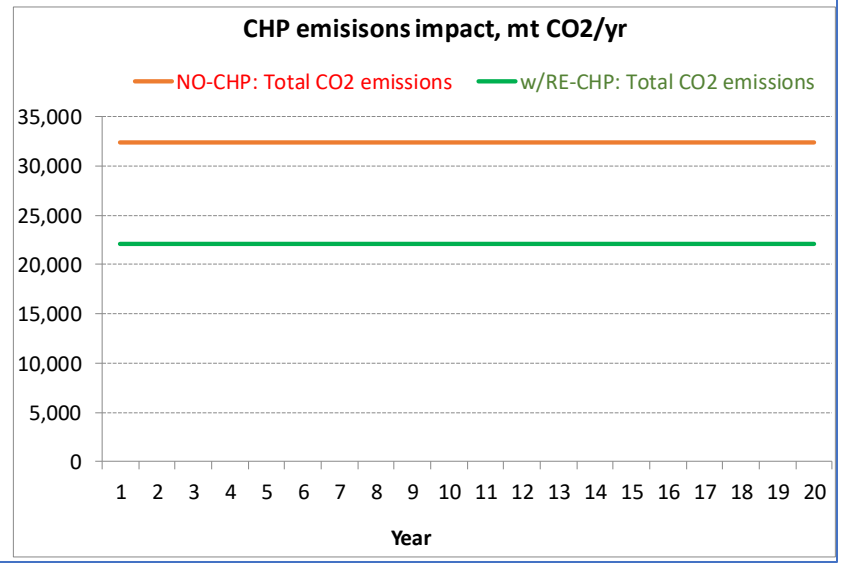
INPUT		UNIT	VALUE	COMMENT
Natural Gas at "Burner tip"		$/MMBtu, HHV	**$2.76**	assumed
All-in Grid power price		c/KWh	**10.0**	assumed
CHP full-load availability		%	**95%**	assumed
W/CHP, Grid Standby Charges		% of value of CHP pwr	**10%**	assumed
Reciprocating Internal Combustion Engine (RE) CHP				JMS420
Project term		years	**20**	
RE-CHP Project Investment		$/$KW_e$	$2,051	CapEx estimate
# of RE-CHP systems			2	as configured
Iso Power		KW_e	1,429	2858 KWe CHP capacit
CHP project financing				
	Equity:Debt Ratio	%	**25%**	assumed
	Debt Term	years	**7**	assumed
	Cost of Debt	%	**7%**	assumed
Pre-CHP Package Boiler				
Displaced package boiler efficiency		% HHV	**83%**	site data
Package Boiler: Variable Charge/cost		cents/$MMBtu_{th}$	**125**	typical

	OUTPUT	UNIT	VALUE No CHP	VALUE RE-CHP	Difference
Project Financing Structure					
25%	Equity	$MM	-	$1.5	
75%	Debt	$MM	-	$4.4	
100%	**CHP only Investment incl. 10% ITC**	**$MM**	-	**$5.9**	
Site Energy Expense in Year 1					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$3.7	$3.2	**$0.5**
Site Energy Expense over Project term 20 years					
	Grid Pwr + fuel + OpEx + Debt Service	$MM	$78.0	$60.0	$18.1
	Multiple of Investment on Equity		-	**12.3**	
HHV Thermodynamic Metrics					
	Efficiency	%	-	61%	
	Electrical Heat Rate	MMBtu/MWh	-	6.8	
	Thermal Energy Rate	$MMBtu/MMBtu_{th}$	-	2.9	
	CHP Thermal Utilization	%	-	63%	

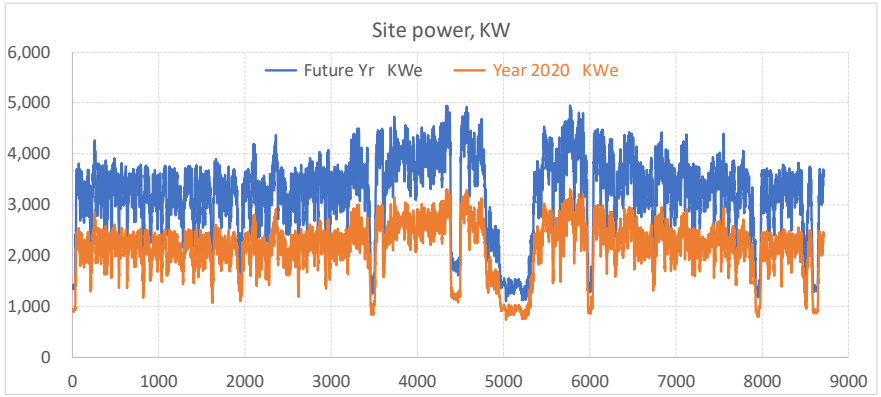


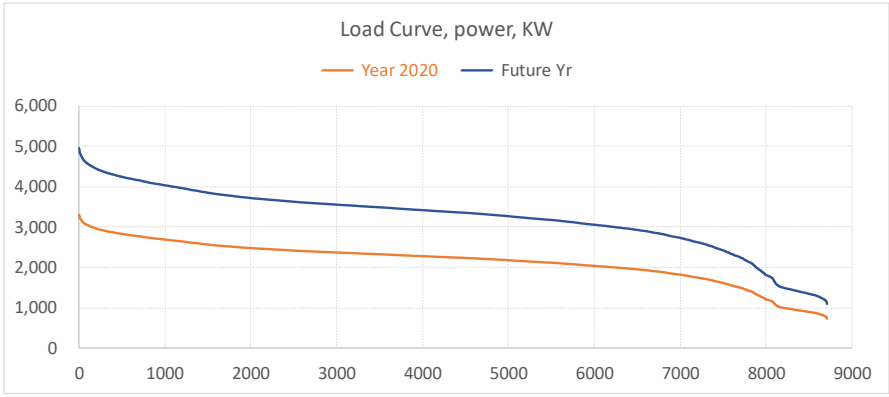


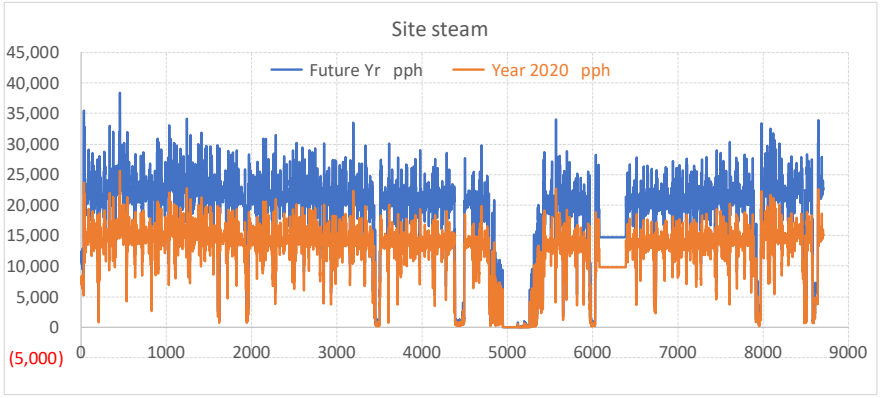


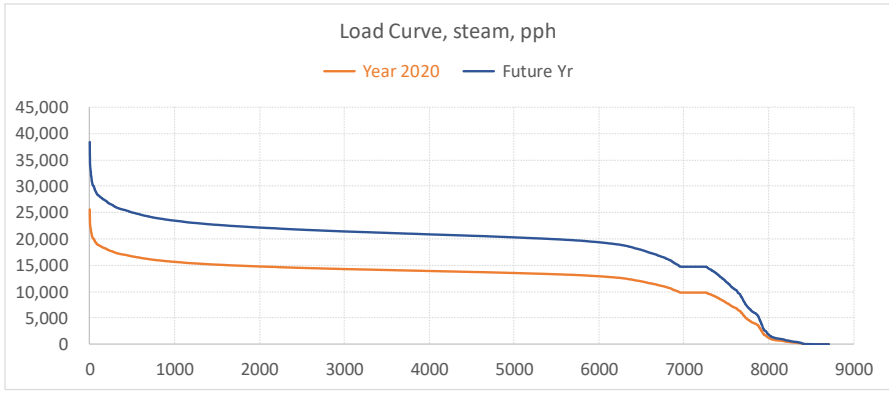


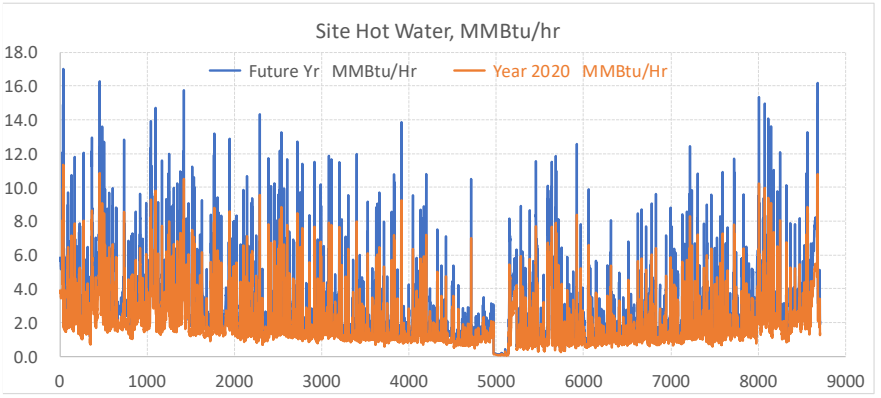
Technical Observation: power & thermal loads correlated. Future yr loads 50% > Year 2020 loads

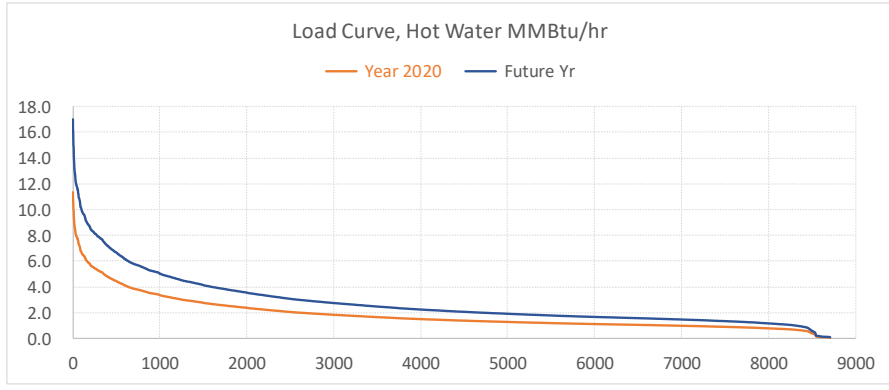












CHP sizing & prime mover selection: Match hourly load (power & thermal energy) to supply

A = B + C

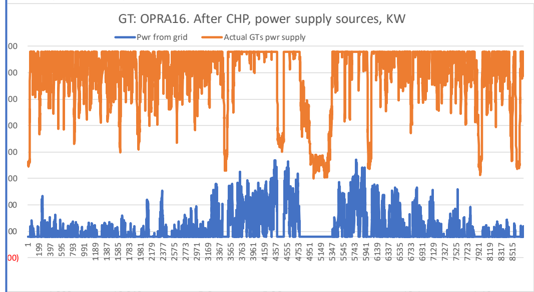
	A	B	C				
50% Load increase					50% Load increase		
NO CHP	NO CHP	NO CHP		NO CHP	NO CHP	NO CHP	NO CHP
grid power	Steam to Header	Hot Water	plant Steam only	Gas to Blrs	CO2: grid	CO2: Blr gas	CO2 total
Future Yr	Future Yr	Future Yr		Future Yr	Future Yr	Future Yr	Future Yr
KWe	pph	MMBtu/Hr	MMBtu/Hr	HHV Dth/hr	mt CO2	mt CO2	mt CO2
28,092,640	160,325,860	24,242	137,148	193,164	22,184	10,264	32,448
4,951	38,388	17.0	32.9	46.3	3.9	2.5	5.2
1,096	-	0.1	-	-	0.9	-	0.9
3,226	18,409	2.78	15.75	22.18	2.55	1.18	3.73
8,709	8,709	8,709	8,709	8,709	8,709	8,709	8,709
758	6,843	2.0	6.4	8.2	0.6	0.4	0.9
KWe	pph	MMBtu/Hr	MMBtu/Hr	HHV Dth/hr	mt CO2	mt CO2	mt CO2
1,408	11,438	5.7	5.70	13.8	1.11	0.73	1.8
1,371	12,386	5.8	6.55	14.9	1.08	0.79	1.9
1,350	10,847	5.8	5.08	13.1	1.07	0.69	1.8
1,389	10,879	5.7	5.21	13.1	1.10	0.70	1.8
						0.69	1.8
						0.72	
						0.71	
						0.68	
						0.71	
						0.66	
						0.71	
						0.69	
						0.64	
						0.61	
						0.62	
						0.61	
						0.61	
						0.66	
						0.82	
						0.65	
						0.69	
						0.69	
1,393	10,840	5.6	5.26	13.1	1.10	0.69	1.8
1,390	10,442	5.5	4.90	12.6	1.10	0.67	1.8
1,389	10,322	5.5	4.81	12.4	1.10	0.66	1.8
1,389	10,945	5.6	5.32	13.2	1.10	0.70	1.8
1,401	10,848	5.8	5.02	13.1	1.11	0.69	1.8
1,384	10,911	5.8	5.14	13.1	1.09	0.70	1.8
1,429	10,833	5.6	5.20	13.1	1.13	0.69	1.8
1,470	11,415	5.7	5.76	13.8	1.16	0.73	1.9
1,412	7,785	5.5	2.32	9.4	1.12	0.50	1.6
1,864	28,078	12.1	16.00	33.8	1.47	1.80	3.3
2,119	30,896	9.3	21.64	37.2	1.67	1.98	3.7
2,409	35,461	8.9	26.52	42.7	1.90	2.27	4.2
2,255	23,445	8.8	14.64	28.2	1.78	1.50	3.3
2,166	21,752	6.4	15.33	26.2	1.71	1.39	3.1
2,312	22,221	6.4	15.83	26.8	1.83	1.42	3.2
2,530	28,147	14.9	13.25	33.9	2.00	1.80	3.8
2,608	21,674	10.7	10.95	26.1	2.06	1.39	3.4
2,947	24,905	11.2	13.67	30.0	2.33	1.59	3.9
3,244	32,816	17.0	15.80	39.5	2.56	2.10	4.7
3,547	25,745	11.9	13.87	31.0	2.80	1.65	4.4
3,406	15,794	3.4	12.43	19.0	2.69	1.01	3.7
3,183	24,764	5.2	19.53	29.8	2.51	1.59	4.1
3,324	20,358	5.2	15.11	24.5	2.63	1.30	3.9
3,443	22,033	2.6	19.46	26.5	2.72	1.41	4.1
3,564	24,377	5.7	18.71	29.4	2.81	1.56	4.4
3,696	22,288	6.4	15.90	26.9	2.92	1.43	4.3
3,563	21,267	2.4	18.83	25.6	2.81	1.36	4.2
3,350	21,247	2.7	18.50	25.6	2.65	1.36	4.0
3,339	21,694	2.7	18.96	26.1	2.64	1.39	4.0
3,538	21,433	2.5	18.93	25.8	2.79	1.37	4.2
3,603	21,254	2.4	18.85	25.6	2.85	1.36	4.2
3,682	21,239	2.5	18.74	25.6	2.91	1.36	4.3
3,501	21,098	2.4	18.69	25.4	2.76	1.35	4.1
3,449	18,338	2.3	15.99	22.1	2.72	1.17	3.9
3,361	21,317	2.4	18.94	25.7	2.65	1.36	4.0

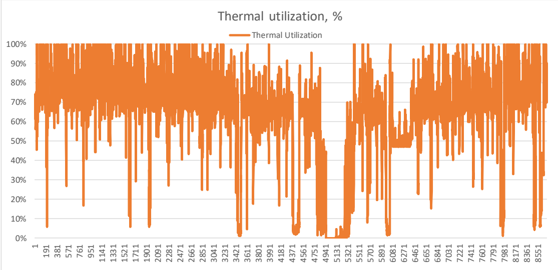
ENERGY SUPPLY PROFILE: Primary supply = CHP. Backup supply = GRID & Nat. Gas Boilers

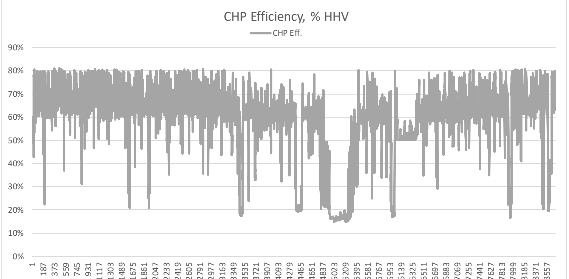
	CHP as 2 x OPRA16		CHP as 2 x OPRA16			CHP as 2 x OPRA16	
	Namplate GTs pwr installed	Actual site power load	Pwr from grid	Actual GTs pwr supply	GTs pwr as	Each GT HR at load	Fuel to GTs
	KWe	KWe	KWe	KWe	% of max	Btu/KWh	MMBtu/Hr
	3500						
TOTAL	30,481,500	28,092,640	1,288,477	26,804,163	-	137,615,869	415,850
MAX	3,500	4,951	1,451	3,500	100%	22,967	53.2
MIN	3,500	1,096	-	1,096	31%	15,112	25.2
AVERAGE	3,500	3,226	148	3,078	88%	15,802	47.7
COUNT	8,709	8,709	8,709	8,709	8,709	8,709	8,709
Std. dev	-	758	268	615	0	1,571	7
	KW_e	KW_e	KW_e	KW_e	% of max	Btu/KWh	MMBtu/Hr
	3,500	1,408	0	1,408	40%	20,865	29.4
	3,500	1,371	0	1,371	39%	21,099	28.9
	3,500	1,350	0	1,350	39%	21,235	28.7
	3,500	1,389	0	1,389	40%	20,983	29.2
	3,500	1,394	0	1,394	40%	20,956	29.2
						20,887	
						21,055	
						21,060	
						20,983	
						21,100	
						21,041	
						21,250	
						21,041	
						21,338	
						20,943	
						20,806	
						20,976	
						20,926	
						20,827	
						20,744	
						20,795	
						20,854	
	3,500	1,393	0	1,393	40%	20,960	
	3,500	1,390	0	1,390	40%	20,980	29.2
	3,500	1,389	0	1,389	40%	20,988	29.1
	3,500	1,389	0	1,389	40%	20,988	29.1
	3,500	1,401	0	1,401	40%	20,913	29.3
	3,500	1,384	0	1,384	40%	21,016	29.1
	3,500	1,429	0	1,429	41%	20,739	29.6
	3,500	1,470	0	1,470	42%	20,487	30.1
	3,500	1,412	0	1,412	40%	20,842	29.4
	3,500	1,864	0	1,864	53%	18,382	34.3
	3,500	2,119	0	2,119	61%	17,298	36.7
	3,500	2,409	0	2,409	69%	16,328	39.3
	3,500	2,255	0	2,255	64%	16,808	37.9
	3,500	2,166	0	2,166	62%	17,122	37.1
	3,500	2,312	0	2,312	66%	16,621	38.4
	3,500	2,530	0	2,530	72%	16,009	40.5
	3,500	2,608	0	2,608	75%	15,827	41.3
	3,500	2,947	0	2,947	84%	15,278	45.0
	3,500	3,244	0	3,244	93%	15,112	49.0
	3,500	3,547	47	3,500	100%	15,207	53.2
	3,500	3,406	0	3,406	97%	15,147	51.6
	3,500	3,183	0	3,183	91%	15,122	48.1
	3,500	3,324	0	3,324	95%	15,118	50.3
	3,500	3,443	0	3,443	98%	15,167	52.2
	3,500	3,564	64	3,500	100%	15,207	53.2
	3,500	3,696	196	3,500	100%	15,207	53.2
	3,500	3,563	63	3,500	100%	15,207	53.2
	3,500	3,350	0	3,350	96%	15,125	50.7
	3,500	3,339	0	3,339	95%	15,122	50.5
	3,500	3,538	38	3,500	100%	15,207	53.2
	3,500	3,603	103	3,500	100%	15,207	53.2
	3,500	3,682	182	3,500	100%	15,207	53.2
	3,500	3,501	1	3,500	100%	15,207	53.2
	3,500	3,449	0	3,449	99%	15,171	52.3
	3,500	3,361	0	3,361	96%	15,129	50.9

	A	B	C	CHP as 2 x OPRA16				CHP as 2 x OPRA16		
	Actual site Thermal load	As Hot Water	As Steam only	GTs W.Ht available	% WH recov. as LP steam	Max. steam available	Thermal Utilization	Actual Steam from HRSGs	Low-temp WH wasted	CHP Eff.
	MMBtu/Hr	MMBtu/Hr	MMBtu/Hr	MMBtu/Hr	%of avail.WH			MMBtu/Hr	MMBtu/Hr	% HHV
TOTAL	160,326	24,242	137,148	324,368	-	241,601	-	159,492	164,875	-
MAX	38.4	17.0	32.9	41.3	76%	31.2	100%	31.2	36.9	81%
MIN	-	0.1	-	21.4	68%	14.6	0%	-	8.0	15%
AVERAGE	18.4	2.8	15.7	37.2	74%	27.7	64%	18.3	18.9	59%
COUNT	8,709	8,709	8,709	8,709	8,709	8,709	8,709	8,709	8,709	8,709
Std. dev	7	2	6	5	0	4	0	7	5	0
	MMBtu/Hr	MMBtu/Hr	MMBtu/Hr	MMBtu/Hr	%of avail.WH	MMBtu/Hr	%	MMBtu/Hr	MMBtu/Hr	% HHV
					HRSG Pinch					
	11.4	5.7	5.7	24.6	69%	17.0	67%	11.4	13.1	55%
	12.4	5.8	6.5	24.2	69%	16.8	74%	12.4	11.9	59%
	10.8	5.8	5.1	24.1	69%	16.6	65%	10.8	13.2	54%
	10.9	5.7	5.2	24.4	69%	16.9	64%	10.9	13.5	54%
	10.8	5.7	5.1	24.5	69%	16.9	64%	10.8	13.6	53%
						17.0	66%	11.2	13.4	54%
						16.8	66%	11.1	13.2	55%
						16.8	63%	10.6	13.7	53%
						16.9	66%	11.2	13.3	55%
						16.8	61%	10.2	14.0	52%
						16.8	66%	11.1	13.2	54%
						16.6	65%	10.8	13.2	54%
						16.8	59%	9.9	14.4	50%
						16.5	58%	9.5	14.4	49%
						16.9	57%	9.7	14.8	49%
						17.1	56%	9.6	15.1	49%
						16.9	57%	9.6	14.8	49%
						16.9	61%	10.3	14.1	52%
						17.1	75%	12.9	11.8	60%
						17.1	59%	10.1	14.6	51%
						17.1	63%	10.7	14.0	53%
						17.0	63%	10.7	13.9	53%
						16.9	64%	10.8	13.6	53%
	10.4	5.5	4.9	24.4	69%	16.9	62%	10.4	14.0	52%
	10.3	5.5	4.8	24.4	69%	16.9	61%	10.3	14.1	52%
	10.9	5.6	5.3	24.4	69%	16.9	65%	10.9	13.5	54%
	10.8	5.8	5.0	24.5	69%	17.0	64%	10.8	13.7	53%
	10.9	5.8	5.1	24.4	69%	16.8	65%	10.9	13.5	54%
	10.8	5.6	5.2	24.8	69%	17.2	63%	10.8	13.9	53%
	11.4	5.7	5.8	25.1	69%	17.4	66%	11.4	13.7	55%
	7.8	5.5	2.3	24.6	69%	17.0	46%	7.8	16.8	43%
	28.1	12.1	16.0	27.9	71%	19.7	100%	19.7	8.2	76%
	30.9	9.3	21.6	29.4	71%	21.0	100%	21.0	8.4	77%
	35.5	8.9	26.5	31.1	72%	22.5	100%	22.5	8.6	78%
	23.4	8.8	14.6	30.2	72%	21.7	100%	21.7	8.5	77%
	21.8	6.4	15.3	29.7	71%	21.2	100%	21.2	8.5	77%
	22.2	6.4	15.8	30.5	72%	22.0	100%	22.0	8.6	78%
	28.1	14.9	13.2	31.9	73%	23.1	100%	23.1	8.7	78%
	21.7	10.7	11.0	32.4	73%	23.6	92%	21.7	10.7	74%
	24.9	11.2	13.7	35.0	74%	25.8	96%	24.9	10.1	78%
	32.8	17.0	15.8	38.0	75%	28.4	100%	28.4	9.6	80%
	25.7	11.9	13.9	41.3	76%	31.2	83%	25.7	15.5	71%
	15.8	3.4	12.4	40.0	75%	30.1	53%	15.8	24.2	53%
	24.8	5.2	19.5	37.3	75%	27.8	89%	24.8	12.5	74%
	20.4	5.2	15.1	38.9	75%	29.2	70%	20.4	18.6	63%
	22.0	2.6	19.5	40.5	75%	30.5	72%	22.0	18.4	65%
	24.4	5.7	18.7	41.3	76%	31.2	78%	24.4	16.9	68%
	22.3	6.4	15.9	41.3	76%	31.2	72%	22.3	19.0	64%
	21.3	2.4	18.8	41.3	76%	31.2	68%	21.3	20.0	62%
	21.2	2.7	18.5	39.2	75%	29.5	72%	21.2	18.0	64%
	21.7	2.7	19.0	39.1	75%	29.3	74%	21.7	17.4	66%
	21.4	2.5	18.9	41.3	76%	31.2	69%	21.4	19.8	63%
	21.3	2.4	18.9	41.3	76%	31.2	68%	21.3	20.0	62%
	21.2	2.5	18.7	41.3	76%	31.2	68%	21.2	20.0	62%
	21.1	2.4	18.7	41.3	76%	31.2	68%	21.1	20.2	62%
	18.3	2.3	16.0	40.6	75%	30.6	60%	18.3	22.2	58%
	21.3	2.4	18.9	39.4	75%	29.6	72%	21.3	18.1	64%

	HHV Blr Eff. 83%		
CHP as 2 x OPRA16			
Actual Steam from boilers	Fuel to Blrs	TOTAL Fuel: GT+Blrs	
MMBtu/Hr	MMBtu/Hr	MMBtu/Hr	
834	1,004	416,855	TOTAL
15.3	18.4	58.9	MAX
-	-	25.2	MIN
0.1	0.1	47.9	AVERAGE
8,709	8,709	8,709	COUNT
1	1	7	Std. dev
MMBtu/Hr	MMBtu/Hr	MMBtu/Hr	
0.0	0.0	29.4	
0.0	0.0	28.9	
0.0	0.0	28.7	
0.0	0.0	29.2	
0.0	0.0	29.2	
0.0	0.0	29.3	
0.0	0.0	29.0	
0.0	0.0	29.0	
0.0	0.0	29.2	
0.0	0.0	28.9	
0.0	0.0	29.0	
0.0	0.0	28.6	
0.0	0.0	29.0	
0.0	0.0	28.5	
0.0	0.0	29.2	
0.0	0.0	29.5	
0.0	0.0	29.2	
0.0	0.0	29.3	
0.0	0.0	29.5	
0.0	0.0	29.6	
0.0	0.0	29.5	
0.0	0.0	29.4	
0.0	0.0	29.2	
0.0	0.0	29.2	
0.0	0.0	29.1	
0.0	0.0	29.1	
0.0	0.0	29.3	
0.0	0.0	29.1	
0.0	0.0	29.6	
0.0	0.0	30.1	
0.0	0.0	29.4	
8.4	10.1	44.4	
9.9	11.9	48.6	
13.0	15.6	55.0	
1.8	2.1	40.0	
0.5	0.6	37.7	
0.3	0.3	38.7	
5.0	6.0	46.5	
0.0	0.0	41.3	
0.0	0.0	45.0	
4.4	5.4	54.4	
0.0	0.0	53.2	
0.0	0.0	51.6	
0.0	0.0	48.1	
0.0	0.0	50.3	
0.0	0.0	52.2	
0.0	0.0	53.2	
0.0	0.0	53.2	
0.0	0.0	53.2	
0.0	0.0	50.7	
0.0	0.0	50.5	
0.0	0.0	53.2	
0.0	0.0	53.2	
0.0	0.0	53.2	
0.0	0.0	53.2	
0.0	0.0	52.3	
0.0	0.0	50.9	



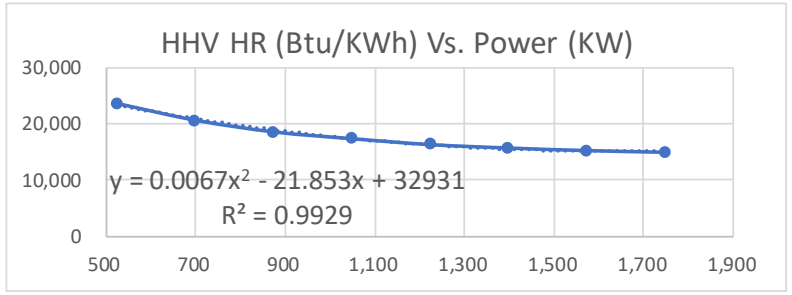


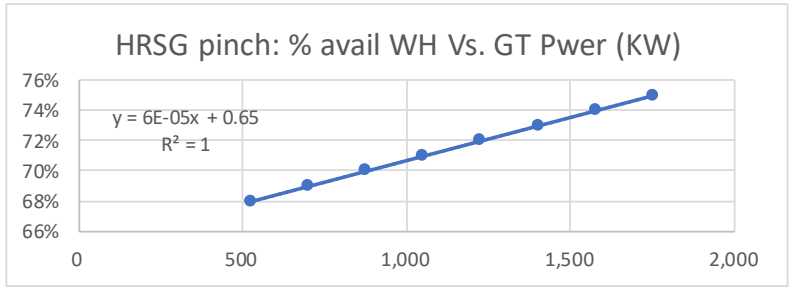


Prime mover (GT, RE) ambient temperature performance curves

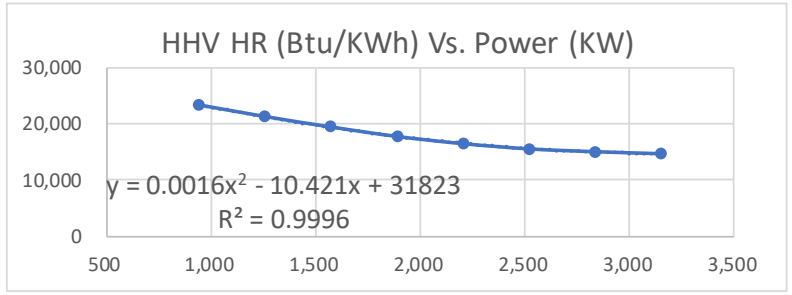
Heat Rate Vs. power and Vs % Waste Heat Recovered vs. power estimated from vendor data at ambient conditions.
Winter electrical overperformance balances summer electrical underperformance (especially fir GTs)

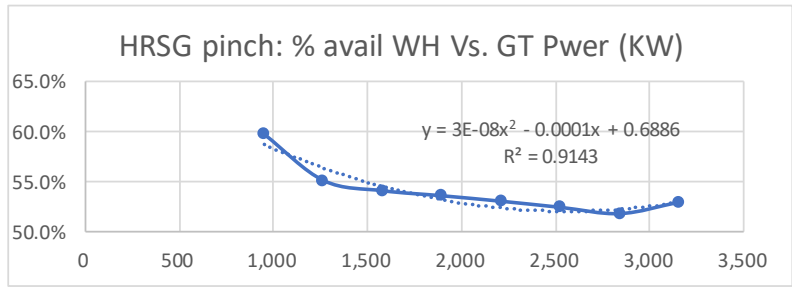
OPRA16 % of max pwr	Power KW	HHV HR Btu/KWh		HRSG- pinch % of avail
100%	**1,750**	**15,002**		**75%**
90%	1,575	15,302	2.0%	74%
80%	1,400	15,752	2.9%	73%
70%	1,225	16,352	3.7%	72%
60%	1,050	17,403	6.0%	71%
50%	875	18,603	6.5%	70%
40%	700	20,658	9.9%	69%
30%	525	23,628	12.6%	68%



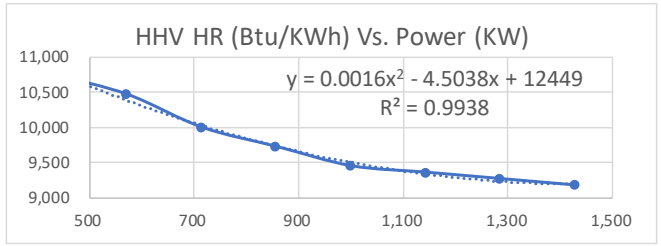


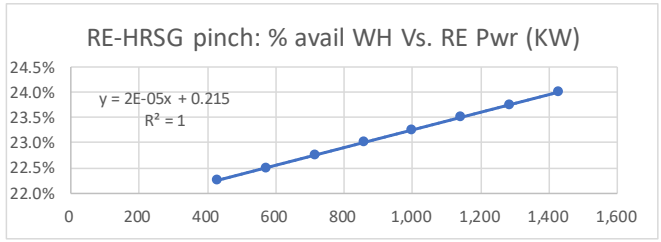
Centaur40 % of max pwr	Power KW	HHV HR Btu/KWh		HRSG- pinch % of avail WH
100%	**3,159**	**14,695**		52.9%
90%	2,843	15,050	2.4%	51.8%
80%	2,527	15,542	3.3%	52.4%
70%	2,211	16,457	5.9%	53.0%
60%	1,895	17,726	7.7%	53.6%
50%	1,580	19,398	9.4%	54.1%
40%	1,264	21,250	9.5%	55.1%
30%	948	23,300	9.6%	59.7%

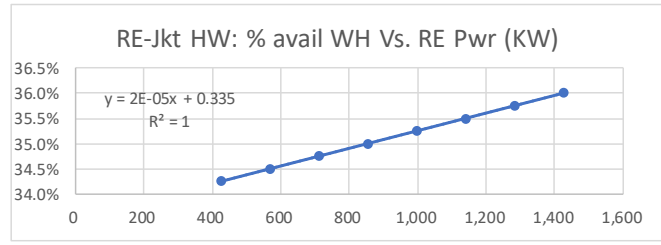




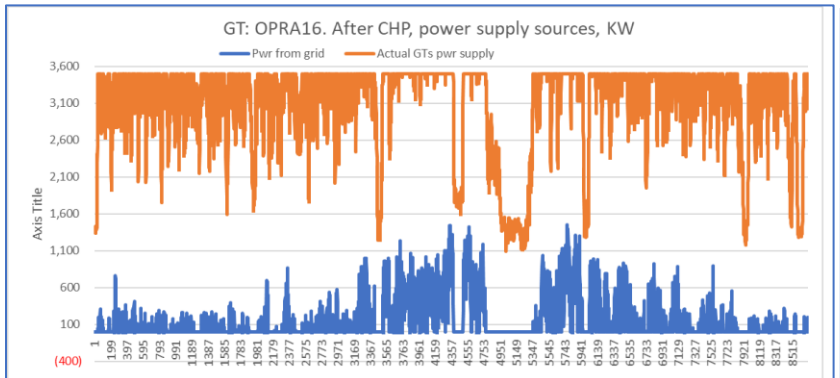
JMS420 % of max pwr	Power KW	HHV HR Btu/KWh		RE-HRSG- pinch % of avail	Jkt HW % of avail
100%	**1,429**	**9,175**		**24.0%**	**36.0%**
90%	1,286	9,266	1.0%	23.8%	35.8%
80%	1,143	9,358	1.0%	23.5%	35.5%
70%	1,000	9,450	1.0%	23.3%	35.3%
60%	857	9,725	2.8%	23.0%	35.0%
50%	715	10,000	2.8%	22.8%	34.8%
40%	572	10,471	4.5%	22.5%	34.5%
30%	429	10,762	2.7%	22.3%	34.3%

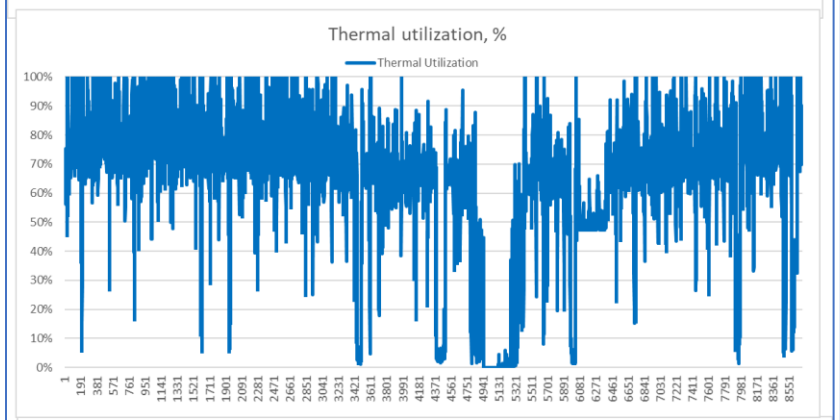


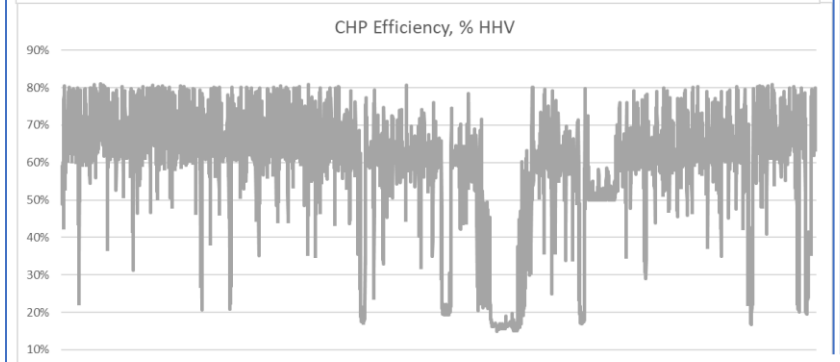


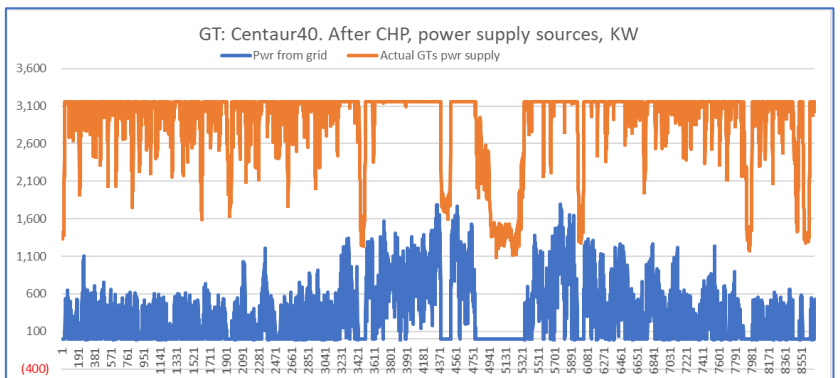


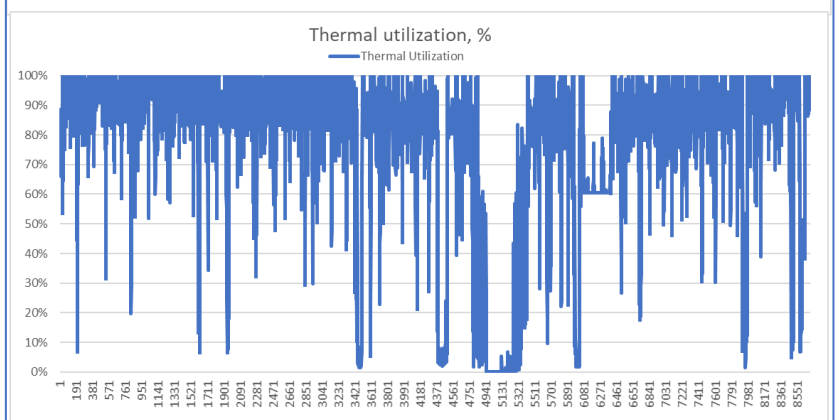
Technical characteristics: ponder CHP efficiency, wasted heat and power capacity

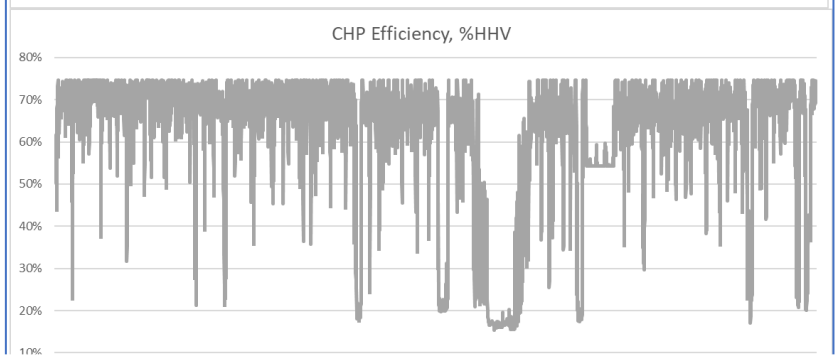


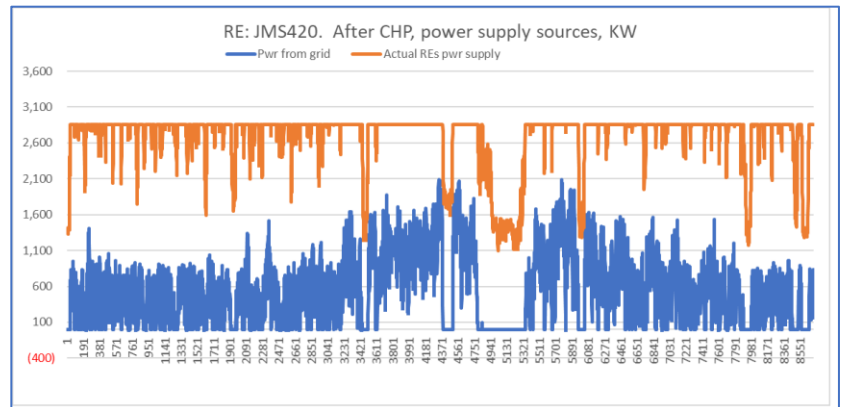


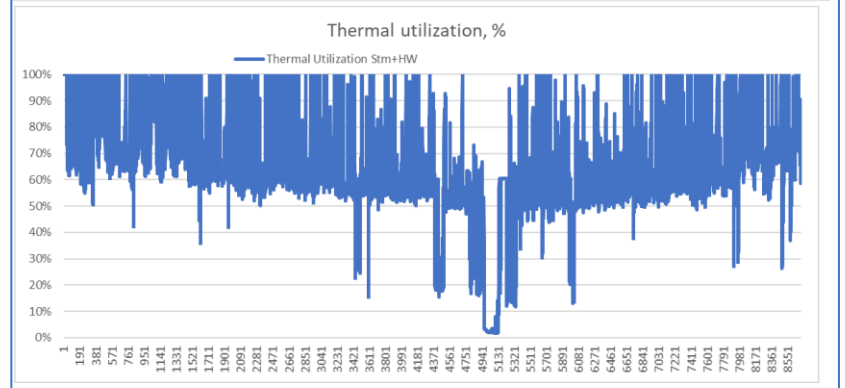


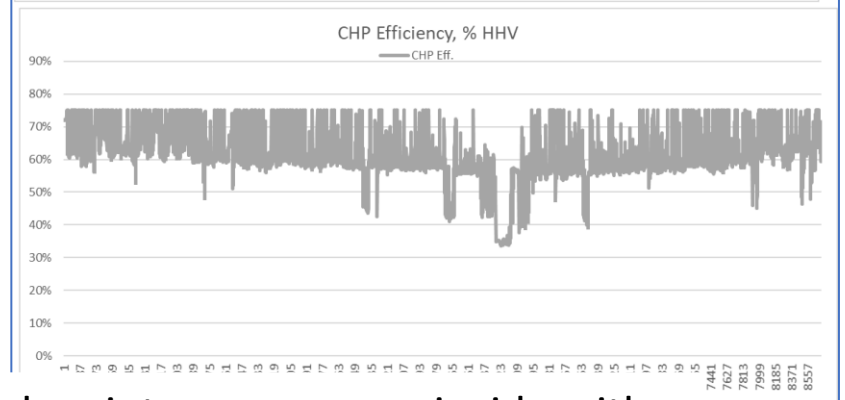












IMPORTANT: CHP Efficiency will exceed calculated efficiency shown if CHP scheduled maintenance can coincide with plant annual 2-weeks shutdown; hence excluding period of low load and hence low CHP efficiency

Selection metrics? Change in fuel, capacity, GHG reduction, CapEx (*next few slides*)

INPUT	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	**50%**	2020 base year
CHP Configuration	# GTs	2	OPRA16
Each GT nominal power	KW_e	1,750	**3500 KWe CHP capacity**
GT-CHP annual availability	%	97%	

OUTPUT - ANNUAL	UNIT	No CHP	w/CHP	Change	% change
Elec. from Grid	MWh	28,093	2,093		
Elec. from CHP	MWh	**0**	26,000		
TOT. Elec.	**MWh**	**28,093**	**28,093**	0	**0%**
Thermal from Blrs	MMBtu	160,326	5,618		
CHP Thermal (HRSG)	MMBtu	**0**	154,707		
TOT. Thermal supply	**MMBtu**	**160,326**	**160,326**	0	**0%**
Fuel to Blrs	MMBtu	193,164	6,769		
Fuel to CHP	MMBtu	**0**	403,375		
TOT. Fuel	**MMBtu**	**193,164**	**410,144**	216,980	**112%**
CO2 Emissions: grid	MT CO_2	22,184	1,652		
CO2 Emissions: fuel	MT CO_2	10,264	21,794		
CO2 TOTAL emissions	**MT CO_2**	**32,448**	**23,446**	(9,002)	**-28%**
Overall CHP Efficiency	**% HHV**		**60%**		
CHP Thermal Utilization	**%**		**64%**		

Full-scope maintenance

INPUTS	2 x OPRA16	COMMENT
Fired Hrs/yr	8,497	
$/fired.hr	**$35.00**	Internal Est.

RESULTS	2 x OPRA16
MWh/yr	26,000
$/MWh	$22.9
cents/KWh	2.29
$K/yr	$594,804

INPUT	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	**50%**	2020 base year
CHP Configuration	# GTs	1	Centaur40
Each GT power at site cdns	KW_e	3,159	**3159 KWe CHP capacity**
GT-CHP annual availability	%	95%	

OUTPUT - ANNUAL	UNIT	No CHP	w/CHP	Change	% change
Elec. from Grid	MWh	28,093	4,110		
Elec. from CHP	MWh	**0**	23,982		
TOT. Elec.	**MWh**	**28,093**	**28,093**	0	**0%**
Thermal from Blrs	MMBtu	160,326	10,923		
CHP Thermal (HRSG)	MMBtu	**0**	149,403		
TOT. Thermal supply	**MMBtu**	**160,326**	**160,326**	0	**0%**
Fuel to Blrs	MMBtu	193,164	13,161		
Fuel to CHP	MMBtu	**0**	365,005		
TOT. Fuel	**MMBtu**	**193,164**	**378,166**	185,002	**96%**
CO2 Emissions: grid	MT CO_2	22,184	3,246		
CO2 Emissions: fuel	MT CO_2	10,264	20,094		
CO2 TOTAL emissions	**MT CO_2**	**32,448**	**23,340**	(9,108)	**-28%**
Overall CHP Efficiency	**% HHV**		**63%**		
CHP Thermal Utilization	**%**		**77%**		

Full-scope maintenance

INPUTS	1 x Centaur40	COMMENT
Fired Hrs/yr	8,322	
$/fired.hr	**$32.00**	5-18-2021 call/Kevin Jensen

RESULTS	1 x Centaur40
MWh/yr	23,982
$/MWh	$11.1
cents/KWh	1.11
$K/yr	$266,304

INPUT	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	**50%**	2020 base year
CHP Configuration	# REs	**2**	JMS420
Each RE nominal power	KW_e	**1,429**	**2858 KWe CHP capacity**
RE-CHP annual availability	%	**95%**	

OUTPUT - ANNUAL	UNIT	No CHP	w/CHP	Change	% change
Elec. from Grid	MWh	28,093	5,877		
Elec. from CHP	MWh	**0**	22,215		
TOT. Elec.	**MWh**	**28,093**	**28,093**	0	**0%**
Thermal from Blrs	MMBtu	160,326	109,140		
CHP Thermal (HRSG, Jkt HW)	MMBtu	**0**	51,186		
TOT. Thermal supply	**MMBtu**	**160,326**	**160,326**	0	**0%**
Fuel to Blrs	MMBtu	193,164	131,494		
Fuel to CHP	MMBtu	**0**	207,094		
TOT. Fuel	**MMBtu**	**193,164**	**338,587**	145,424	**75%**
CO2 Emissions: grid	MT CO_2	22,184	4,641		
CO2 Emissions: fuel	MT CO_2	10,264	17,991		
CO2 TOTAL emissions	**MT CO_2**	**32,448**	**22,633**	(9,816)	**-30%**
Overall CHP Efficiency	**% HHV**		**61%**		
CHP Thermal Utilization	**%**		**63%**		

Full-scope maintenance

INPUTS	2 x JMS420	COMMENT
Fired Hrs/yr	8,322	
$/fired.hr	**$27.68**	per vendor

RESULTS	2 x JMS420
MWh/yr	22,215
$/MWh	$20.7
cents/KWh	2.07
$K/yr	$460,706

Above maintenance figures exclude additional expense for non-CHP equipment maintenance, consumables and staff

IMPORTANT: CHP Efficiency will exceed calculated efficiency shown if CHP scheduled maintenance can coincide with plant annual 2-weeks shutdown; hence excluding period of low load and hence low CHP efficiency

CHP configuration: 2 x Gas Turbine as OPRA16; slightly increased CHP availability

Cost metric	On/Off			Unit Cost $MM	Quantity	Extd. Cost $MM	COMMENT
		A. Equipment					
$1,000	1	Gas Turbine	**2 x OPRA16**	$1.75	2	$3.50	OPRA GT, Elec (Switchgear, MCC, breakers), utility tie-in, Gas Compressor, No DA, HRSG (no duct-burner)
44%		GT-HRSG		$0.77	2	$1.54	
18%		Gas Compressor		$0.32	2	$0.63	
$600	0	~~Reciprocating Engine~~		~~$0.00~~	~~2~~	~~$0.00~~	
25%		~~RE-HRSG/HRU~~		~~$0.00~~	~~2~~	~~$0.00~~	
		Other		$0.00	1	$0.00	
		Sub-total		**$2.84**		**$5.67**	
		B. Balance of Plant (BOP)					
35%		Civil, Mech, Electrical, I&C etc..		$0.99	1	$0.99	SJ est.; edit after FEL3
14%		Eqpmt x'port to site, unload & siting		$0.40	1	$0.40	SJ est.; edit after FEL3
		Other		$0.00	1	$0.00	
		Sub-total		**$1.39**		**$1.39**	
		C. Indirect ("Soft") costs					
20%		Engg, PM/CM		$0.84	1	$0.84	ST budgetary; edit after FEL3
8%		Legal/Env. & permitting		$0.34	1	$0.34	SJ est.; edit after FEL3
3%		Bonding, Insurance		$0.13	1	$0.13	SJ est.; edit after FEL3
30%		Financing, Wkg Cpts, Devp. Fee etc…		$1.27	1	$1.27	SJ est.; edit after FEL3
		Other		$0.00	1	$0.00	
		Sub-total		**$2.58**		**$2.58**	
20%		**D. Contingency**		**$1.36**	1	$1.36	missing scope items
		E. CHP ONLY INVESTMENT		**$8.16**		**$11.00**	$3142 /KW
	1	**F. 10% Investment Tax Credit (ITC)**				**($1.10)**	ITC applies to CHP investment
		G. CHP ONLY INVESTMENT including 10% ITC				**$9.90**	**$2828 /KW**

Cost, $MM	On/Off	NON-CHP CAPEX ADDs & OFFSETS	$MM	COMMENT
$2.00	0	Site upgrade: electrical infrastructure	$0.00	Host to add / delete specific non-CHP CapEx line items per host analysis of resiliency (redunancy + availability) required
$1.00	0	New package boiler	$0.00	
$0.90	0	Diesel b/u (Gen-set, fuel tank, pump skid)	$0.00	
$0.35	0	Onsite propane fuel tank + fuel pump skid	$0.00	
$0.00	0	other	$0.00	
$0.00	0	Other	$0.00	
		H. SUB-TOTAL	**$0.00**	**$0 /KW**
		I. OVERALL PROJECT INVESTMENT	**$9.90**	**$2828 /KW**

INPUT	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	**50%**	2020 base year
CHP Configuration	# GTs	2	OPRA16
Each GT nominal power	KW_e	1,750	**3500 KWe CHP capacity**
GT-CHP annual availability	%	97%	

OUTPUT - ANNUAL	UNIT	No CHP	w/CHP	Change	% change
Elec. from Grid	MWh	28,093	2,093		
Elec. from CHP	MWh	**0**	26,000		
TOT. Elec.	**MWh**	**28,093**	**28,093**	0	**0%**
Thermal from Blrs	MMBtu	160,326	5,618		
CHP Thermal (HRSG)	MMBtu	**0**	154,707		
TOT. Thermal supply	**MMBtu**	**160,326**	**160,326**	0	**0%**
Fuel to Blrs	MMBtu	193,164	6,769		
Fuel to CHP	MMBtu	**0**	403,375		
TOT. Fuel	**MMBtu**	**193,164**	**410,144**	216,980	**112%**
CO2 Emissions: grid	MT CO_2	22,184	1,652		
CO2 Emissions: fuel	MT CO_2	10,264	21,794		
CO2 TOTAL emissions	**MT CO_2**	**32,448**	**23,446**	**(9,002)**	**-28%**
Overall CHP Efficiency	**% HHV**		**60%**		
CHP Thermal Utilization	**%**		**64%**		

Full-scope maintenance

INPUTS	2 x OPRA16	COMMENT
Fired Hrs/yr	8,497	
$/fired.hr	**$35.00**	Internal Est.

RESULTS	2 x OPRA16
MWh/yr	26,000
$/MWh	$22.9
cents/KWh	2.29
$K/yr	$594,804

Several small GT choices available and OPRA16 is indicative selection only

CHP configuration: 1 x Gas Turbine as Centaur40

Cost metric	On/Off			Unit Cost $MM	Quantity	Extd. Cost $MM	COMMENT
		A. Equipment					
$917	1	Gas Turbine	**1 x Centaur40**	$2.90	1	$2.90	C40 GT, Elec (Switchgear, MCC, breakers), utility tie-in, Gas Compressor, No DA, HRSG (no duct-burner)
45%		GT-HRSG		$1.30	1	$1.30	
23%		Gas Compressor		$0.67	1	$0.67	
$600	0	~~Reciprocating Engine~~		~~$0.00~~	~~1~~	~~$0.00~~	
25%		~~RE-HRSG/HRU~~		~~$0.00~~	~~1~~	~~$0.00~~	
		Other		$0.00	1	$0.00	
		Sub-total		**$4.87**		**$4.87**	
		B. Balance of Plant (BOP)					
20%		Civil, Mech, Electrical, I&C etc..		$0.97	1	$0.97	ST budgetary; edit after FEL3
8%		Eqpmt x'port to site, unload & siting		$0.39	1	$0.39	ST budgetary; edit after FEL3
		Other		$0.00	1	$0.00	
		Sub-total		**$1.36**		**$1.36**	
		C. Indirect ("Soft") costs					
10%		Engg, PM/CM		$0.62	1	$0.62	ST budgetary; edit after FEL3
5%		Legal/Env. & permitting		$0.31	1	$0.31	SJ est.; edit after FEL3
2%		Bonding, Insurance		$0.12	1	$0.12	SJ est.; edit after FEL3
20%		Financing, Wkg Cpts, Devp. Fee etc…		$1.25	1	$1.25	SJ est.; edit after FEL3
		Other		$0.00	1	$0.00	
		Sub-total		**$2.30**		**$2.30**	
20%		**D. Contingency**		**$1.71**	1	$1.71	missing scope items
		E. CHP ONLY INVESTMENT		**$10.24**		**$10.24**	**$3242 /KW**
	1	**F. 10% Investment Tax Credit (ITC)**				**($1.02)**	ITC applies to CHP investment
		G. CHP ONLY INVESTMENT including 10% ITC				**$9.22**	**$2918 /KW**

Cost, $MM	On/Off	NON-CHP CAPEX ADDs & OFFSETS	$MM	COMMENT
$2.00	0	Site upgrade: electrical infrastructure	$0.00	
$1.00	0	New package boiler	$0.00	
$0.90	0	Diesel b/u (Gen-set, fuel tank, pump skid)	$0.00	Host to add / delete specific non-CHP CapEx line items per host analysis of resiliency (redunancy + availability) required
$0.35	0	Onsite propane fuel tank + fuel pump skid	$0.00	
$0.00	0	other	$0.00	
$0.00	0	Other	$0.00	
		H. SUB-TOTAL	**$0.00**	**$0 /KW**
		I. OVERALL PROJECT INVESTMENT	**$9.22**	**$2918 /KW**

INPUT	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	**50%**	2020 base year
CHP Configuration	# GTs	1	Centaur40
Each GT power at site cdns	KW_e	3,159	**3159 KWe CHP capacity**
GT-CHP annual availability	%	95%	

OUTPUT - ANNUAL	UNIT	No CHP	w/CHP	Change	% change
Elec. from Grid	MWh	28,093	4,110		
Elec. from CHP	MWh	**0**	23,982		
TOT. Elec.	**MWh**	**28,093**	**28,093**	0	**0%**
Thermal from Blrs	MMBtu	160,326	10,923		
CHP Thermal (HRSG)	MMBtu	**0**	149,403		
TOT. Thermal supply	**MMBtu**	**160,326**	**160,326**	0	**0%**
Fuel to Blrs	MMBtu	193,164	13,161		
Fuel to CHP	MMBtu	**0**	365,005		
TOT. Fuel	**MMBtu**	**193,164**	**378,166**	185,002	**96%**
CO2 Emissions: grid	MT CO_2	22,184	3,246		
CO2 Emissions: fuel	MT CO_2	10,264	20,094		
CO2 TOTAL emissions	**MT CO_2**	**32,448**	**23,340**	**(9,108)**	**-28%**
Overall CHP Efficiency	**% HHV**		**63%**		
CHP Thermal Utilization	**%**		**77%**		

Full-scope maintenance

INPUTS	1 x Centaur40	COMMENT
Fired Hrs/yr	8,322	
$/fired.hr	**$32.00**	5-18-2021 call/Kevin Jensen

RESULTS	1 x Centaur40
MWh/yr	23,982
$/MWh	$11.1
cents/KWh	1.11
$K/yr	$266,304

Several small GT choices available and Centaur40 is indicative selection only

CHP configuration: 2 x Reciprocating Engine as JMS420 / 1429 KW

Cost metric	On/Off			$MM		$MM	
		A. Equipment					
$750	0	~~Gas Turbine~~		~~$0.00~~	~~2~~	~~$0.00~~	
25%		~~RE-HRSG~~		~~$0.00~~	~~2~~	~~$0.00~~	
0%		Gas Compressor		$0.00	2	$0.00	Enclosure, Fuel gas train, LV alternator, Gen. Circ. Brkr, HW HXs, HRSG, , SCR system, SCADA system, deliv. To site, Installation assistance, commissioning & FAT, O&M manual & dwgs etc…
$1,025	1	Reciprocating Engine	**2 x JMS420**	$1.46	2	$2.93	
0%		RE-HRSG/HRU		$0.00	2	$0.00	
		Other		$0.00	1	$0.00	
		Sub-total		**$1.46**		**$2.93**	
		B. Balance of Plant (BOP)					
50%		Civil, Mech, Electrical, I&C etc..		$0.73	1	$0.73	SJ est.; edit after FEL3
20%		Eqpmt x'port to site, unload & siting		$0.29	1	$0.29	SJ est.; edit after FEL3
		other		$0.00	1	$0.00	
		Sub-total		**$1.03**		**$1.03**	
		C. Indirect ("Soft") costs					
25%		Engg, PM/CM		$0.62	1	$0.62	SJ est.; edit after FEL3
10%		Legal/Env. & permitting		$0.25	1	$0.25	SJ est.; edit after FEL3
4%		Bonding, Insurance		$0.10	1	$0.10	SJ est.; edit after FEL3
30%		Financing, Wkg Cptl, Devp. Fee etc…		$0.75	1	$0.75	SJ est.; edit after FEL3
		Other		$0.00	1	$0.00	
		Sub-total		**$1.72**		**$1.72**	
20%		**D. Contingency**		**$0.84**	1	$0.84	missing scope items
		E. CHP ONLY INVESTMENT		**$5.05**		**$6.51**	**$2279 /KW**
	1	**F. 10% Investment Tax Credit (ITC)**				**($0.65)**	ITC applies to CHP investment
		G. CHP ONLY INVESTMENT including 10% ITC				**$5.86**	**$2051 /KW**

Cost, $MM	On/Off	NON-CHP CAPEX ADDs & OFFSETS	$MM	COMMENT
$2.00	0	Site upgrade: electrical infrastructure	$0.00	
$1.00	0	New package boiler	$0.00	Host to add / delete specific non-CHP CapEx line items per host analysis of resiliency (redunancy + availability) required
$0.90	0	Diesel b/u (Gen-set, fuel tank, pump skid)	$0.00	
$0.35	0	Onsite propane fuel tank + fuel pump skid	$0.00	
$0.00	0	other	$0.00	
$0.00	0	Other	$0.00	
		H. SUB-TOTAL	**$0.00**	**$0 /KW**
		I. OVERALL PROJECT INVESTMENT	**$5.86**	**$2051 /KW**

INPUT	UNIT	VALUE	COMMENT
FUTURE baseline site Load	% load increase	**50%**	2020 base year
CHP Configuration	# REs	**2**	JMS420
Each RE nominal power	KW_e	**1,429**	**2858 KWe CHP capacity**
RE-CHP annual availability	%	**95%**	

OUTPUT - ANNUAL	UNIT	No CHP	w/CHP	Change	% change
Elec. from Grid	MWh	28,093	5,877		
Elec. from CHP	MWh	**0**	22,215		
TOT. Elec.	**MWh**	**28,093**	**28,093**	0	**0%**
Thermal from Blrs	MMBtu	160,326	109,140		
CHP Thermal (HRSG, Jkt HW)	MMBtu	**0**	51,186		
TOT. Thermal supply	**MMBtu**	**160,326**	**160,326**	0	**0%**
Fuel to Blrs	MMBtu	193,164	131,494		
Fuel to CHP	MMBtu	**0**	207,094		
TOT. Fuel	**MMBtu**	**193,164**	**338,587**	145,424	**75%**
CO2 Emissions: grid	MT CO_2	22,184	4,641		
CO2 Emissions: fuel	MT CO_2	10,264	17,991		
CO2 TOTAL emissions	**MT CO_2**	**32,448**	**22,633**	(9,816)	**-30%**
Overall CHP Efficiency	**% HHV**		**61%**		
CHP Thermal Utilization	**%**		**63%**		

Full-scope maintenance

INPUTS	2 x JMS420	COMMENT
Fired Hrs/yr	8,322	
$/fired.hr	**$27.68**	per vendor

RESULTS	2 x JMS420
MWh/yr	22,215
$/MWh	$20.7
cents/KWh	2.07
$K/yr	$460,706

Several RE choices available (eg: CAT, MAN, Progen (EMD series)etc…..) and JMS420 is indicative selection only

NEXT STEPS

Present investment proposal to Management; include Project Execution Plan (PEP), key Risks & mitigants, recommend a project financing structure (eg: on-balance sheet, 3rd party financing, other)

If approved, i.e. Limited Notice to Proceed (LNTP),

- Assemble Project team
- Issue RFP to equipment vendors; select engineering firm, owners engineer
- Update financial model; add after-tax cash flows
- Engage local utility (power & gas), community
- Meet with local permitting entities, assess permit pathway & start negotiating permit.

- Improve project economics by:
  - Explore selling waste heat to Ind. Facility to the north (*especially for 2 x RE and 2 x GT cases*)
  - Apply for grants & incentives at www.dsireusa.org
  - If available, finance project using PACE funds (very long-duration & low-interest). *Repayments are a tax-deductible add-on to site property tax bill.*
  - Negotiate volumetric discount on natural gas delivery charge
  - Factor beneficial economics of avoided investments on electrical infrastructure & thermal (boilers)
  - Explore monetizing greenhouse gas emissions (GHG) reductions

Deliverable & milestone: Final Notice to Proceed (FNTP); begin Equipment procurement, engineering & construction

Stage Gate Process: Front End Loaded (FEL)

FEL STAGE	FEL1: Business Assessment	FEL2: Alternatives Selection. *Conceptual Engineering*	FEL3: Scope Definition. *Basic Engineering*	FEL4: Engineering, Procurement & Construction Management (EPCM). *Detailed Engineering+*	FEL5: Commissioning & Operations & Evaluation
PURPOSE	Identify projects aligned with business objectives	Select preferred process & technology options	Complete scope definiton: validate business premises, ensure project execution with a degree of certainty	Implement Project Execution Plan (PEP)	Meet design nameplate; evaluate against business objectives
OBJECTIVES	Define business premises	Validate business premises	Finalize scope of work, schedule and cost	Complete Detailed Engineering	Achieve nameplate production
	Define project objectives	Analyze alternate process & technology options; select best alternative	Value engineering for cost reduction	Secure required permits	
	List assumptions - technical & commerical	Develop Process scope of work	Mitigation of risks & uncertainties	Create equipment procurement plan	
	Identify risks & state mitigants	Process Flow Diagram with Heat & Mass Balance (PFD + HMB)	Project Execution Plan (PEP)	Mobilize construction resources - project / construction manager, prime contractor & sub-contractors	
	Preliminary economics	Utilities availability ("gap analysis")	Gather project team	EHS management	
	Justify & prioritize projects	Identify uncertainties & risks	Secure project funding	Checkout & commissioning	
DELIVERABLES	FEL 1 deliverables check list	FEL 2 deliverables check list	FEL 3 deliverables check list	Commissioned project	
	Abstract / objectives statement	Basic economic model	Major equipment list & specifications with firm quotes	Purchase & receive equipment & bulk materials, manage construction to support PEP	Collect operating data
	Resource assignment	PFD + HMB, basic plot plan	Finalize plot plan	Manage change orders	Capture formal lessons learned
	Project manager	Permitting requirements & strategy	Issue for design: P&ID, control lists, electrical 1-line diagrams		
	Project Engineer	O&M strategy	Conduct HAZOP review	Final HAZOP review	Capture process improvements for future projects
	Other	EHS requirements & strategy	EHS requirements & strategy		
		Technical risk assessment	Project Execution Plan (PEP) with Work BreakDown Structure (WBS) & sub-contracting plan		Prepare for project close-out
		Major equipment list and key vendors			
	CapEx: Order of magnitude. ± 50%	CapEx: Conceptual estimate +35% -20%	CapEx: quasi-investment grade estimate +15% -5%		
	O&M, G&A: Order of magnitude. ± 50%	O&M, G&A: conceptual estimate. ± 25%	O&M, G&A: estimate ± 15%		
	FEL2 plan with milestone schedule	FEL3 plan with milestone schedule	Detailed construction schedule		
COSTS	$1,000 <= co$t <=$5,000	0.3% <= $ TIC <= 1.0%	0.7% <= $ TIC <= 3.0%	3.0% <= $ Engineering <= 15.0% rest for Procurement & construction	Funded from O&M,G&A budget
FUNDING SOURCE	Owner expensed	Owner expensed	Owner expensed or capitalized	Capitalized	
DURATION	1 <= days <=5	2 <= weeks <=12	6 <= weeks <=18	6 <= months <=24	

GLOSSARY

O&M, GA	Operations & maintenance, General & Administrative	TIC	Total Installed Cost
PFD+ HMB	Process Flow Diagram + Heat & Mass Balance	HAZOP	Hazard & Operability Analysis

Example emissions calculation for permitting & sizing the Emissions Control System (ECS)

INPUT	UNIT	VALUE Gas Turbine	VALUE HRSG-DB	VALUE Pkge Blr
Exhaust Pollutants				
NO_x	ppmv	308	33	33
CO	ppmv	23	10	30
UHC	ppmv	5	5	5
$PM_{2.5}$	ppmv	7	7	7
%O2 after GT, hrsg-DB, Blr stack	**%**	**15.0%**	**3.5%**	**3.5%**
Pollutant Properies - Molar Weight				
NOx	lb/lb-mol	46		
CO	lb/lb-mol	28		
UHC	lb/lb-mol	16	assumed CH4	
PM2.5	lb/lb-mol	25	assumed	
Flue Gas properties				
Molar Volume	dscf / lb-mol	379.7	1-atm & 60F	
Fd Factor	dscf / MMBtu	8,608	NG:1050 Btu/scf @60F	
CHP: Effectiveness of Pollution Control component				
SCR only in CHP		80%	assumed	
COR only in CHP		80%	assumed	

OUTPUT		UNIT	VALUE Gas Turbine	VALUE HRSG-DB	VALUE CHP total	Poll. Ctrl	VALUE Exit Stack HRSG	VALUE Exit Stack Pkge Blr	VALUE Exit Stack TOTAL SITE
Exhaust Pollutants									
NOx	7.5557849	lb/MMBtu HHV	1.138	0.041	1.179	80% SCR	0.236	0.041	**0.277**
CO	0.3434448	lb/MMBtu HHV	0.052	0.008	0.059	80% COR	0.012	0.023	**0.035**
UHC		lb/MMBtu HHV	0.006	0.002	0.009	-	0.009	0.002	**0.011**
PM2.5		lb/MMBtu HHV	0.014	0.005	0.019	-	0.019	0.005	**0.024**
%O2 after GT, hrsg-DB, Blr stack									

Exhaust Pollutants	UNIT	Gas Turbine	HRSG-DB	CHP total	Poll. Ctrl	HRSG	Pkge Blr	TOTAL SITE
NOx	lb/hr	58.2	4.1	62.3	80% SCR	12.5	0.5	**13**
CO	lb/hr	2.6	0.7	3.4	80% COR	0.7	0.3	**1**
UHC	lb/hr	0.3	0.2	0.5	-	0.5	0.0	**1**
PM2.5	lb/hr	0.7	0.5	1.2	-	1.2	0.1	**1**

Exhaust Pollutants	UNIT	Gas Turbine	HRSG-DB	CHP total	Poll. Ctrl	HRSG	Pkge Blr	TOTAL SITE	
NOx	tons/yr	247.3	17.2	264.5	80% SCR	52.9	2.1	**55**	OK- NOx 27 % below limit
CO	tons/yr	11.2	3.2	14.4	80% COR	2.9	1.1	**4**	OK- CO 84 % below limit
UHC	tons/yr	1.4	0.9	2.3	-	2.3	0.1	**2**	OK- UHC 76 % below limit
PM2.5	tons/yr	3.1	2.0	5.0	-	5.0	0.2	**5**	OK- PM2.5 47 % below limit

INPUT	UNIT	VALUE	COMMENT
# of GT- CHP's		1	1 x XYZ CHP
Each GT power	MW_e	**3.5**	**XYZ**
Each GT Heat Rate	LHV MMBtu/MWWh	**13.3**	XYZ
Entire Site Steam load	**Kpph**	**125**	site data
Pkgr Blr Efficiency	**% LHV**	**86%**	site data
Water-to-Steam Enthalpy Gain	MMBtu/Klb	**1.1**	enter DA, exit Blr
Availability (GT-CHP & Pkge Blr)	%	**97%**	354 days/yr
High DF Recov. Factor	% unf. WH Recov.	60%	f(pinch, psig, F)
DB Marginal Efficiency	% LHV	99%	typical
Current Permit allowable Emissions			
NOx	tons/yr	75	Assumed
CO	tons/yr	25	Assumed
UHC	tons/yr	10	Assumed
PM2.5	tons/yr	10	Assumed

OUTPUT	UNIT	VALUE Gas Turbine	VALUE HRSG-DB		VALUE CHP TOTAL	VALUE Pkge Blr	VALUE TOTAL SITE
Fuel input	HHV MMBtu/Hr	51	98		149	12	**161**
	HHV MMBtu/yr	434,631	833,043		1,267,674	99,629	**1,367,303**
Steam output	Kpph	19	97		116	9	**125**
	MM lb/yr	160	824		984	78	**1,062**
Check: Unfired Steam	Klb/MWhr			OK	5.4		
Check: Steam Rate	HHV MMBtu/ Klb				1.29		

Example output during FEL3 for permitting & scope definition

Questions?

Suresh Jambunathan
630-335-4544
suresh.jambunathan@enwadev.com