

Appendix B: Economic Analysis Cost Sheets

Appendix B: Cost Sheets

General Equipment Sizes and Costs

Scheme 1

Capital investment and operating costs at bottom of spreadsheet

Pumps and Compressors

WATPUMP

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.001	0.012	0.00	333	
30	2,809	762,584	2.763	33.7	4.21	333	\$2,900
300	28,090	7,625,843	27.633	337.4	42.06	333	\$8,100
1000	93,633	25,419,476	92.111	1124.5	140.20	333	\$14,800

B5 (syncmpr water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.001	0.011	0.00	510	
30	2,809	762,584	4.018	32.0	3.99	510	\$3,240
300	28,090	7,625,843	40.180	320.3	39.93	510	\$9,720
1000	93,633	25,419,476	133.933	1067.6	133.10	510	\$25,160

B3 (licool water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.001	0.006	0.00	485.304	
30	2,809	762,584	2.004	16.8	2.09	485.304	\$2,590
300	28,090	7,625,843	20.045	167.9	20.93	485.304	\$6,480
1000	93,633	25,419,476	66.816	559.7	69.78	485.304	\$12,580

B7 (psacool water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.000	0.016	0.00	85	
30	2,809	762,584	1.076	45.4	5.67	85	\$1,800
300	28,090	7,625,843	10.758	454.5	56.66	85	\$3,200
1000	93,633	25,419,476	35.861	1515.0	188.88	85	\$5,400

B13 (timgen6 water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.001	0.008	0.00	310	
30	2,809	762,584	1.831	22.1	2.75	310	
300	28,090	7,625,843	16,826	220.7	27.51	310	
1000	93,633	25,419,476	56,088	735.5	91.70	310	

pump1

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.001	0.018	0.00	150	
30	2,809	762,584	1.831	49.6	6.19	150	
300	28,090	7,625,843	18,307	496.2	61.86	150	
1000	93,633	25,419,476	61,023	1,653.8	206.19	150	

pump2

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.001	0.018	0.00	150	
30	2,809	762,584	1.831	49.6	6.19	150	
300	28,090	7,625,843	18,307	496.2	61.86	150	
1000	93,633	25,419,476	61,023	1,653.8	206.19	150	

pump3

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.001	0.018	0.00	150	
30	2,809	762,584	1.831	49.6	6.19	150	
300	28,090	7,625,843	18,307	496.2	61.86	150	
1000	93,633	25,419,476	61,023	1,653.8	206.19	150	

pump4

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	2.49E-05	0.001	0.00	85	
30	2,809	762,584	0.070	3.3	0.42	85	
300	28,090	7,625,843	0.699	33.4	4.17	85	
1000	93,633	25,419,476	2.330	111.4	13.89	85	

pump5

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	271	0.000	0.001	0.00	85	
30	2,809	762,584	0.060	2.9	0.36	85	\$1,500
300	28,090	7,625,843	0.597	28.5	3.56	85	\$1,700
1000	93,633	25,419,476	1.989	95.1	11.86	85	\$2,200

OFFCOMPR

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	cost 1994\$	second stage power hp	cost 1994\$	third stage power hp	cost 1994\$	fourth stage power hp	cost 1994\$	total cost
0.01068	1	271	0.024	0.024	0.02949	0.0281	0.0281	0.0281	0.0281		
30	2,809	762,584	67.2	\$79,100	82.8	\$92,600	78.9	\$89,300	78.9	\$89,300	\$350,300
300	28,090	7,625,843	671.6	\$422,000	828.4	\$494,000	789.3	\$476,400	789.3	\$476,400	\$1,868,800
1000	93,633	25,419,476	2238.8	\$1,042,600	2761.2	\$1,220,500	2631.1	\$1,177,000	2631.1	\$1,177,000	\$4,617,100

SYNCOMPR

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	cost 1994\$	second stage power hp	cost 1994\$	third stage power hp	cost 1994\$	fourth stage power hp	cost 1994\$	total cost
0.01068	1	271	0.01814000	0.018	0.01797	0.01793	0.01793	0.01793	0.01793		
30	2,809	762,584	51.0	\$64,300	50.6	63,900.0	50.5	\$63,800	50.4	\$63,700	\$255,700
300	28,090	7,625,843	509.6	\$342,900	505.6	340,900.0	504.8	\$340,500	503.7	\$340,000	\$1,364,300
1000	93,633	25,419,476	1698.5	\$847,200	1685.4	832,200.0	1682.6	\$841,300	1678.8	\$839,800	\$3,360,500

Heat Exchangers and Heaters

GSTMGEN

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271	632.9	679.2815	192.0261	0.0049	
30	2,809	762,584	1.78E+06	679.2815	192.0261	13.6	\$1,200
300	28,090	7,625,843	1.78E+07	679.2815	192.0261	136.3	\$7,100
1000	93,633	25,419,476	5.93E+07	679.2815	192.0261	454.3	\$13,000

LTCOOOL

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271	365.5	326.6936	85.7387	0.0	
30	2,809	762,584	1.03E+06	326.6936	85.7387	36.7	\$1,300
300	28,090	7,625,843	1.03E+07	326.6936	85.7387	366.5	\$11,300
1000	93,633	25,419,476	3.42E+07	326.6936	85.7387	1221.8	\$26,600

PSACOOOL

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271	967.7	120	85	0.1	
30	2,809	762,584	2.72E+06	120	85	266.5	\$9,300
300	28,090	7,625,843	2.72E+07	120	85	2665.0	\$51,600
1000	93,633	25,419,476	9.06E+07	120	85	8883.2	\$167,800

STMGEN6

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271	485.3	38.57	149.67	0.1	
30	2,809	762,584	1.36E+06	38.57	149.67	236.1	\$8,700
300	28,090	7,625,843	1.36E+07	38.57	149.67	2361.4	\$46,300
1000	93,633	25,419,476	4.54E+07	38.57	149.67	7871.4	\$147,700

SYNCOOL1 / REFHR (MODEL1)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271	27.1	1256.2968	149.6937	0.0	
30	2,809	762,584	7.61E+04	1256.2968	149.6937	0.4	\$1,000
300	28,090	7,625,843	7.61E+05	1256.2968	149.6937	4.0	\$1,100
1000	93,633	25,419,476	2.54E+06	1256.2968	149.6937	13.5	\$1,200

REFSTM / COMBCOOL (MODEL2)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271	901.8	537.7543	186.5534	0.0090	
30	2,809	762,584	2.53E+06	537.7543	186.5534	25.3	\$1,300
300	28,090	7,625,843	2.53E+07	537.7543	186.5534	252.5	\$9,000
1000	93,633	25,419,476	8.44E+07	537.7543	186.5534	841.7	\$20,000

SYNCOMPR INTERSTAGE COOLERS

INTERIA FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatxl duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271		510	28.8	149.6937	0.1183
30	2,809	762,584		1.43E+06	28.8	149.6937	332.3
300	28,090	7,625,843		1.43E+07	28.8	149.6937	3323.0
1000	93,633	25,419,476		4.78E+07	28.8	149.6937	11,076.51

****cost of two identical heat exchangers

INTERIB FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatxl duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271		510	28.8	149.6937	0.1183
30	2,809	762,584		1.43E+06	28.8	149.6937	332.3
300	28,090	7,625,843		1.43E+07	28.8	149.6937	3323.0
1000	93,633	25,419,476		4.78E+07	28.8	149.6937	11076.5

****cost of two identical heat exchangers

INTERIC FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatxl duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	271		510	28.8	149.6937	0.1183
30	2,809	762,584		1.43E+06	28.8	149.6937	332.3
300	28,090	7,625,843		1.43E+07	28.8	149.6937	3323.0
1000	93,633	25,419,476		4.78E+07	28.8	149.6937	11076.5

****cost of two identical heat exchangers

OFFCOMPR INTERSTAGE COOLERS

INTER2A

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	Cost 1994\$
0.01068	1	271	75.9471	71	19.3917	0.0482	
30	2,809	762,584	1.99E+05	75.9471	19.3917	135.4	\$6,700
300	28,090	7,625,843	1.99E+06	75.9471	19.3917	1354.2	\$28,900
1000	93,633	25,419,476	6.65E+06	75.9471	19.3917	4514.0	\$84,400

INTER2B

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	Cost 1994\$
0.01068	1	271	58.4995	60.3	14.4888	0.0711	
30	2,809	762,584	1.69E+05	58.4995	14.4888	199.8	\$8,200
300	28,090	7,625,843	1.69E+06	58.4995	14.4888	1998.4	\$40,000
1000	93,633	25,419,476	5.65E+06	58.4995	14.4888	6661.3	\$124,300

REACTORS

HTSHIFT
 SV (1/hr) = 4000
 height/diameter 2

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	flowrate acfh*	reactor volume ft ³	diameter ft	height ft	pressure psi	Cost 1994\$ SS316
0.01068	1	271	3.13	0.0008	0.08	0.16	504	
30	2,809	762,584	8,804	2.20	1.12	2.24	504	\$6,700
300	28,090	7,625,843	88,039	22.01	2.41	4.82	504	\$26,700
1000	93,633	25,419,476	293,464	73.37	3.60	7.20	504	\$56,200

LTSHIFT

SV (1/hr) = 4000
 height/diameter 2

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	flowrate acfh*	reactor volume ft ³	diameter ft	height ft	pressure psi	Cost 1994\$ SS316
0.01068	1	271	2.54	0.0006	0.07	0.15	427	
30	2,809	762,584	7,122	1.78	1.04	2.09	427	\$5,900
300	28,090	7,625,843	71,219	17.80	2.25	4.49	427	\$23,500
1000	93,633	25,419,476	237,397	59.35	3.36	6.71	427	\$49,400

* acfh = actual cubic feet per hour

PRIMARY REFORMER

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	Heat duty MMBtu/hr	Chem Cost 1994\$	P&T, 3rd ed 1994\$	Chem Eng, Oct 10, 1977 1994\$	avg
0.01068	1	271	5.56E-04				
30	2,809	762,584	1.562	\$53,600			\$53,600
300	28,090	7,625,843	15.620	\$328,600		\$335,800	\$331,300
1000	93,633	25,419,476	52.067	\$878,200	\$329,500	\$987,400	\$926,933

Separation System

PSA SYSTEM

Installed cost of PSA for 4.05 MMSCFD
\$/SCFD

\$1,025,000
0.253

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	H2 produced cost \$
0.01068	1	271	
30	2,809	762,584	\$193,000
300	28,090	7,625,843	\$1,929,997
1000	93,633	25,419,476	\$6,433,324

Gasification (Installed)

cost of a 2200 bone dry ton/day gasification plant: \$12,440,143

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	gasifier plant cost 1994 K\$
0.01068	1	271	
30	2,809	762,584	\$615,339
300	28,090	7,625,843	\$3,084,000
1000	93,633	25,419,476	\$7,163,570

Capital Requirements

Capital expense

	% of purchased equipment cost
Instrumentation	18%
piping	66%
electrical	11%
buildings	18%
yard improvements	10%
service facilities	70%
land	6%
engineering and construction	74%
contingencies	42%

Equipment capital

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	uninstalled capital	Installation cost	other equipment Installed	total equipment cost 1994\$	total uninstalled capital
30	2,809	762,584	\$765,130	\$359,611	\$808,339	\$1,933,080	\$1,315,020
300	28,090	7,625,843	\$4,048,370	\$1,902,734	\$5,013,997	\$10,955,101	\$7,459,252
1000	93,633	25,419,476	\$10,310,613	\$4,845,988	\$13,596,894	\$28,763,495	\$19,560,201

Other fixed capital investment

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	Instrumentation	piping	electrical	buildings	yard	service facilities	land	engineering	contingencies	total related fixed capital
30	2,809	762,584	\$236,704	\$667,913	\$144,652	\$236,704	\$131,502	\$920,514	\$78,901	\$973,115	\$552,308	\$4,142,314
300	28,090	7,625,843	\$1,342,665	\$4,923,107	\$820,518	\$1,342,665	\$745,925	\$5,221,477	\$447,555	\$5,519,847	\$3,132,886	\$23,496,645
1000	93,633	25,419,476	\$3,520,836	\$12,909,733	\$2,151,622	\$3,520,836	\$1,956,020	\$13,692,141	\$1,173,612	\$14,474,549	\$8,215,284	\$61,614,633

Total fixed capital investment

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	fixed capital
30	2,809	762,584	\$6,075,393
300	28,090	7,625,843	\$34,461,747
1000	93,633	25,419,476	\$90,368,129

Working capital

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	working capital
30	2,809	762,584	\$1,093,571
300	28,090	7,625,843	\$6,203,114
1000	93,633	25,419,476	\$16,266,263

Operating costs

electricity cost 0.05 \$/kWh
 on-line factor 0.9

Electricity

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power requireme hp	cost \$/yr
0.01068	1	271	0.188	
30	2,809	762,584	527.391	\$155,044
300	28,090	7,625,843	5273.907	\$1,550,440
1000	93,633	25,419,476	17579.690	\$5,168,134

Water

for gasification 0.45 lb/lb bdw
 for reforming 0.64 lb/lb bdw
 for steam generation 2.97 lb/lb bdw
 BFW cost \$0.33 \$/1000 liters

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	for gasification 1000 liters/year	for reforming 1000 liters/year	for steam generation 1000 liters/year	total BFW 1000 liters/year	cost \$/yr
30	2,809	762,584	2.01	2.86	13.29	18.16	5.99
300	28,090	7,625,843	20.09	28.63	132.89	181.61	59.93
1000	93,633	25,419,476	66.95	95.43	442.97	605.35	199.77

Operating costs of PSA

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	op cost \$/1000 SCF	cost \$/yr
30	2,809	762,584	\$6.50	\$4,957
300	28,090	7,625,843	\$6.50	\$49,568
1000	93,633	25,419,476	\$6.50	\$165,227

Labor

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	operators	formen	supervisors	total labor cost \$/yr
30	2,809	762,584	\$28,700	3	1	\$39,300
300	28,090	7,625,843		6	2	\$155,900
1000	93,633	25,419,476		8	2	\$272,500
						\$329,900

Byproduct credit: steam

500 psig steam stream steam6 total	0.2838 lb/lb dried wood 0.2838
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Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	steam produced lb/hr	steam produced 1000 kg/year	selling price \$/1000 kg	yearly revenue \$
30	2,809	762,584	797	3,167.62	\$7.88	\$24,960.83
300	28,090	7,625,843	7,972	31,676.18	\$7.88	\$249,608.27
1000	93,633	25,419,476	26,573	105,587.26	\$7.88	\$832,027.57

100 psig steam streams steam 1a, 1b, stream steam2a stream steam2b stream steam4 stream steam5 total	1.125 lb/lb dried wood 0.056 lb/lb dried wood 0.048 lb/lb dried wood 0.378 lb/lb dried wood 0.754 lb/lb dried wood 2.36205 lb/lb dried wood
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Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	steam produced lb/hr	steam produced 1000 kg/year	steam produced \$/1000 kg	yearly revenue \$
30	2,809	762,584	6,635	26,363.87	\$5.18	\$136,564.82
300	28,090	7,625,843	66,350	263,638.65	\$5.18	\$1,365,648.22
1000	93,633	25,419,476	221,166	878,795.51	\$5.18	\$4,552,160.74

General Equipment Sizes and Costs

Scheme 2: primary reformer only; no shift converters

Capital investment and operating costs at bottom of spreadsheet
change only those values in blue; others are calculated or imported from somewhere else.

Pumps and Compressors

WATPUMP

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.001	0.012	0.00	333
30	2,809	595,028		2,763	33.7	4.21	333
300	28,090	5,950,281		27,633	337.4	42.06	333
1000	93,633	19,834,270		92,111	1124.5	140.20	333

B5 (syncmpr water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.001	0.011	0.00	510
30	2,809	595,028		4,018	32.0	3.99	510
300	28,090	5,950,281		40,180	320.3	39.93	510
1000	93,633	19,834,270		133,933	1067.6	133.10	510

B3 (lcool water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.001	0.006	0.00	485.304
30	2,809	595,028		2,004	16.8	2.09	485.304
300	28,090	5,950,281		20,045	167.9	20.93	485.304
1000	93,633	19,834,270		66,816	559.7	69.78	485.304

B7 (psacool water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.000	0.016	0.00	85
30	2,809	595,028		1,076	45.4	5.67	85
300	28,090	5,950,281		10,758	454.5	56.66	85
1000	93,633	19,834,270		35,861	1515.0	188.88	85

3 (stimgen6 water pump)

wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.001	0.008	0.00	310
30	2,809	595,028		1.883	22.1	2.75	310
300	28,090	5,950,281		16,826	220.7	27.51	310
1000	93,633	19,834,270		56,088	735.5	91.70	310

ump1

wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.001	0.018	0.00	150
30	2,809	595,028		1.831	49.6	6.19	150
300	28,090	5,950,281		18,307	496.2	61.86	150
1000	93,633	19,834,270		61,023	1653.8	206.19	150

ump2

wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.001	0.018	0.00	150
30	2,809	595,028		1.831	49.6	6.19	150
300	28,090	5,950,281		18,307	496.2	61.86	150
1000	93,633	19,834,270		61,023	1653.8	206.19	150

ump3

wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		0.001	0.018	0.00	150
30	2,809	595,028		1.831	49.6	6.19	150
300	28,090	5,950,281		18,307	496.2	61.86	150
1000	93,633	19,834,270		61,023	1653.8	206.19	150

ump4

wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	212		2.49E-05	0.001	0.00	85
30	2,809	595,028		0.070	3.3	0.42	85
300	28,090	5,950,281		0.699	33.4	4.17	85
1000	93,633	19,834,270		2.330	111.4	13.89	85

pump5

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft3/hr	flowrate gal/min	delta P psl	cost 1994\$
0.01068	1	212	0.001	0.000	0.001	0.00	85
30	2,809	595,028	2.9	0.060	2.9	0.36	85
300	28,090	5,950,281	28.5	0.597	28.5	3.56	85
1000	93,633	19,834,270	95.1	1.989	95.1	11.86	85

OFFCOMPR

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	cost 1994\$	second stage power hp	cost 1994\$	third stage power hp	cost 1994\$	fourth stage power hp	cost 1994\$	total cost 1994\$
0.01068	1	212	0.018	0.02213	0.02109	0.02109	0.02109	0.02109	0.02109	0.02109	\$6,810
30	2,809	595,028	50.4	62.2	\$60,300	\$70,600	\$70,600	\$68,100	\$68,100	\$68,100	\$205,810
300	28,090	5,950,281	503.9	621.6	\$340,100	\$398,100	\$398,100	\$384,000	\$384,000	\$384,000	\$1,506,200
1000	93,633	19,834,270	1679.8	2072.1	\$840,200	\$987,700	\$987,700	\$948,800	\$948,800	\$948,800	\$3,725,500

SYNCOMPR

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	cost 1994\$	second stage power hp	cost 1994\$	third stage power hp	cost 1994\$	fourth stage power hp	cost 1994\$	total cost 1994\$
0.01068	1	212	0.0161	0.01598	0.01596	0.01596	0.01596	0.01596	0.01593	0.01593	\$55,100
30	2,809	595,028	45.2	44.9	\$55,000	53300.0	53300.0	\$55,200	44.7	44.7	\$220,600
300	28,090	5,950,281	452.2	448.9	\$313,500	311800.0	311800.0	\$311,500	447.5	447.5	\$947,800
1000	93,633	19,834,270	1507.5	1496.3	\$774,600	770300.0	770300.0	\$769,500	1491.6	1491.6	\$3,082,900

Heat Exchangers and Heaters

STMGEN

Wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	632.9	679.2815	192.0261	0.0049	
30	2,809	595,028	1.78E+06	679.2815	192.0261	13.6	\$1,200
300	28,090	5,950,281	1.78E+07	679.2815	192.0261	136.3	\$7,100
1000	93,633	19,834,270	5.93E+07	679.2815	192.0261	454.3	\$13,000

SACCOOL

Wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	365.5	326.6936	85.7387	0.0	
30	2,809	595,028	1.03E+06	326.6936	85.7387	36.7	\$1,300
300	28,090	5,950,281	1.03E+07	326.6936	85.7387	366.5	\$11,300
1000	93,633	19,834,270	3.42E+07	326.6936	85.7387	1221.8	\$26,600

SACCOOL

Wood feed one dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	967.7	120	85	0.1	
30	2,809	595,028	2.72E+06	120	85	266.5	\$9,300
300	28,090	5,950,281	2.72E+07	120	85	2665.0	\$51,600
1000	93,633	19,834,270	9.06E+07	120	85	8883.2	\$167,800

STMGEN6

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	485.3	38.57	149.67	0.1	
30	2,809	595,028	1.36E+06	38.57	149.67	236.1	\$8,700
300	28,090	5,950,281	1.36E+07	38.57	149.67	2361.4	\$46,300
1000	93,633	19,834,270	4.54E+07	38.57	149.67	7871.4	\$147,700

SYNCOOLI / REFHR (MODEL1)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	27.1	1256.2968	149.6937	0.0	
30	2,809	595,028	7.61E+04	1256.2968	149.6937	0.4	\$1,000
300	28,090	5,950,281	7.61E+05	1256.2968	149.6937	4.0	\$1,100
1000	93,633	19,834,270	2.54E+06	1256.2968	149.6937	13.5	\$1,200

REFSTM / COMBPOOL (MODEL2)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	901.8	537.7543	186.5534	0.0090	
30	2,809	595,028	2.53E+06	537.7543	186.5534	25.3	\$1,300
300	28,090	5,950,281	2.53E+07	537.7543	186.5534	252.5	\$9,000
1000	93,633	19,834,270	8.44E+07	537.7543	186.5534	841.7	\$20,000

YNCOMPR INTERSTAGE COOLERS

INTERIA FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatx1 duty Btu/hr	delta T1m °F	Avg U Btu/hr/sqft	area sqft	Cost 1994\$
0.01068	1	212	510	28.8	149.6937	0.1183	
30	2,809	595,028	1.43E+06	28.8	149.6937	332.3	\$11,100
300	28,090	5,950,281	1.43E+07	28.8	149.6937	3323.0	\$63,100
1000	93,633	19,834,270	4.78E+07	28.8	149.6937	11,076.51	\$206,400

****cost of two identical heat exchangers

INTERIB FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatx1 duty Btu/hr	delta T1m °F	Avg U Btu/hr/sqft	area sqft	Cost 1994\$
0.01068	1	212	510	28.8	149.6937	0.1183	
30	2,809	595,028	1.43E+06	28.8	149.6937	332.3	\$11,100
300	28,090	5,950,281	1.43E+07	28.8	149.6937	3323.0	\$63,100
1000	93,633	19,834,270	4.78E+07	28.8	149.6937	11076.5	\$206,400

****cost of two identical heat exchangers

INTERIC FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatx1 duty Btu/hr	delta T1m °F	Avg U Btu/hr/sqft	area sqft	Cost 1994\$
0.01068	1	212	510	28.8	149.6937	0.1183	
30	2,809	595,028	1.43E+06	28.8	149.6937	332.3	\$11,100
300	28,090	5,950,281	1.43E+07	28.8	149.6937	3323.0	\$63,100
1000	93,633	19,834,270	4.78E+07	28.8	149.6937	11076.5	\$206,400

****cost of two identical heat exchangers

OFFCOMPR INTERSTAGE COOLERS

INTER2A

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta T _{lm} °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	71	75.9471	19.3917	0.0482	
30	2,809	595,028	1.99E+05	75.9471	19.3917	135.4	\$6,700
300	28,090	5,950,281	1.99E+06	75.9471	19.3917	1354.2	\$28,900
1000	93,633	19,834,270	6.65E+06	75.9471	19.3917	4514.0	\$84,400

INTER2B

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta T _{lm} °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	212	60.3	58.4995	14.4888	0.0711	
30	2,809	595,028	1.69E+05	58.4995	14.4888	199.8	\$8,200
300	28,090	5,950,281	1.69E+06	58.4995	14.4888	1998.4	\$40,000
1000	93,633	19,834,270	5.65E+06	58.4995	14.4888	6661.3	\$124,300

REACTORS

PRIMARY REFORMER

Wood feed one dry tpd	Wood feed dried lb/hr	H ₂ produced scfd	Heat duty MMBtu/hr	Chem Cost 1994\$	P&T, 3rd ed 1994\$	Chem Eng, Oct 10, 1977 1994\$	avg
0.01068	1	212	5.56E-04				
30	2,809	595,028	1.562	\$53,600			\$53,600
300	28,090	5,950,281	15.620	\$328,600	\$329,500	\$335,800	\$331,300
1000	93,633	19,834,270	52.067	\$878,200	\$915,200	\$987,400	\$926,933

Preparation System

PSA SYSTEM

Installed cost of PSA for 4.05 MMSCFD
/SCFD

0.01068	1	212	\$1,025,000			
30	2,809	595,028	0.253			
300	28,090	5,950,281				
1000	93,633	19,834,270				

Gasification (Installed)
 cost of a 2200 bone dry ton/day gasification plant: \$12,440,143

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	gasifier plant cost 1994 K\$
0,01068	1	212	
30	2,809	595,028	\$615,339
300	28,090	5,950,281	\$3,084,000
1000	93,633	19,834,270	\$7,163,570

Capital Requirements

% of purchased equipment cost

- 18%
- 66%
- 11%
- 18%
- 10%
- 70%
- 6%
- 74%
- 42%

- capital expense
- instrumentation
- ping
- electrical
- buildings
- ard Improvements
- ervice facilities
- nd
- ngineering and construction
- ontingencies

equipment capital

Wood feed dried lb/hr	H2 produced scfd	uninstalled capital	Installation cost	other equipment installed	total equipment cost 1994\$	total uninstalled capital
30	2,809	\$572,940	\$269,282	\$765,932	\$1,608,154	\$1,093,982
300	28,090	\$3,219,070	\$1,512,963	\$4,589,935	\$9,321,968	\$6,341,475
1000	93,633	\$9,035,813	\$4,246,832	\$12,183,354	\$25,466,000	\$17,323,809

other fixed capital investment

Wood feed dried lb/hr	H2 produced scfd	Instrumentation	piping	electrical	buildings	yard	service facilities	land	engineering	contingencies	total fixed capital
30	2,809	\$196,917	\$722,028	\$120,338	\$196,917	\$109,398	\$765,788	\$65,639	\$809,547	\$459,473	\$3,446,045
300	28,090	\$1,141,465	\$4,185,373	\$697,562	\$1,141,465	\$634,147	\$4,439,032	\$380,488	\$4,692,691	\$2,663,419	\$19,975,646
1000	93,633	\$3,118,286	\$11,433,714	\$1,905,619	\$3,118,286	\$1,732,381	\$12,126,667	\$1,039,429	\$12,819,619	\$7,276,000	\$54,569,999

total fixed capital investment

Wood feed dried lb/hr	H2 produced scfd	fixed capital
30	2,809	\$5,054,199
300	28,090	\$29,297,614
1000	93,633	\$80,035,999

Working capital

Wood feed dried lb/hr	H2 produced scfd	working capital
30	2,809	\$909,756
300	28,090	\$5,273,571
1000	93,633	\$14,406,480

18% of the capital expenditures estimated so far.

Operating costs

electricity cost 0.05 \$/kWh
 on-line factor 0.9

Electricity

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power requiremet hp	cost \$/yr
0.01068	1	212	0.152	
30	2,809	595,028	427.896	\$125,794
300	28,090	5,950,281	4278.963	\$1,257,943
1000	93,633	19,834,270	14263.210	\$4,193,145

Water

for gasification 0.45 lb/lb bdw
 for reforming 0.64 lb/lb bdw
 for steam generation 2.97 lb/lb bdw
 BFW cost \$0.33 \$/1000 liters

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	for gasification 1000 liters/year	for reforming 1000 liters/year	for steam generation 1000 liters/year	total BFW 1000 liters/year
30	2,809	595,028	2.01	2.86	13.29	18.16
300	28,090	5,950,281	20.09	28.63	132.89	181.61
1000	93,633	19,834,270	66.95	95.43	442.97	605.35

Operating costs of PSA

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	op cost \$/1000 SCF	cost \$/yr
30	2,809	595,028	\$6.50	\$3,868
300	28,090	5,950,281	\$6.50	\$38,677
1000	93,633	19,834,270	\$6.50	\$128,923

labor

Wood feed moone dry tpd	Wood feed dried lb/hr	H2 produced scfd	personnel and their cost per year			total labor cost \$/yr	
			operators	formen	supervisors		
30	2,809	595,028	\$28,700	\$30,500	\$39,300	1	\$155,900
300	28,090	5,950,281	6	2		1	\$272,500
1000	93,633	19,834,270	8	2		1	\$329,900

Byproduct credit: steam

500 psig steam stream steam6 total	0.2838 lb/lb. dried wood 0.2838	Wood feed dried lb/hr	H2 produced scfd	steam produced lb/hr	steam produced 1000 kg/year	selling price \$/1000 kg	yearly revenue \$
30	2,809	595,028	797	3,167.62	\$7.88	\$24,960.83	
300	28,090	5,950,281	7,972	31,676.18	\$7.88	\$249,608.27	
1000	93,633	19,834,270	26,573	105,587.26	\$7.88	\$832,027.57	

100 psig steam
stream steam1a
stream steam2a
stream steam2b
stream steam4

1.125 lb/lb dried wood
0.056499 lb/lb dried wood
0.048249 lb/lb dried wood
0.378

stream steam5 total	0.754 lb/lb dried wood 2.362048	Wood feed dried lb/hr	H2 produced scfd	steam produced lb/hr	steam produced 1000 kg/year	selling price \$/1000 kg	yearly revenue \$
		30	2,809	595,028	6,635	26,363.87	\$5.18 \$136,564.82
		300	28,090	5,950,281	66,350	263,638.65	\$5.18 \$1,365,648.22
		1000	93,633	19,834,270	221,166	878,795.51	\$5.18 \$4,552,160.74

General Equipment Sizes and Costs

Scheme 3

Scheme 3: no low temperature shift reactor
Capital investment and operating costs at bottom of spreadsheet

Pumps and Compressors

WATPUMP

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.001	0.012	0.00	333	
30	2,809	721,770	2.763	33.7	4.21	333	\$2,900
300	28,090	7,217,697	27.633	337.4	42.06	333	\$8,100
1000	93,633	24,058,989	92.111	1124.5	140.20	333	\$14,800

B5 (syncmpr water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.001	0.011	0.00	510	
30	2,809	721,770	4.018	32.0	3.99	510	\$3,240
300	28,090	7,217,697	40.180	320.3	39.93	510	\$9,720
1000	93,633	24,058,989	133.933	1067.6	133.10	510	\$25,160

B3 (ftcool water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.001	0.006	0.00	485.304	
30	2,809	721,770	2.004	16.8	2.09	485.304	\$2,590
300	28,090	7,217,697	20.045	167.9	20.93	485.304	\$6,480
1000	93,633	24,058,989	66.816	559.7	69.78	485.304	\$12,580

B7 (psacool water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.000	0.016	0.00	85	
30	2,809	721,770	1.076	45.4	5.67	85	\$1,800
300	28,090	7,217,697	10.758	454.5	56.66	85	\$3,200
1000	93,633	24,058,989	35.861	1516.0	188.88	85	\$5,400

B13 (ftmgcn6 water pump)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	flowrate ft ³ /hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.001	0.008	0.00	310	
30	2,809	721,770	1.683	22.1	2.75	310	\$2,400
300	28,090	7,217,697	16.826	220.7	27.51	310	\$5,670
1000	93,633	24,058,989	56.088	735.5	91.70	310	\$11,340

pump1

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	ff3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.001	0.018	0.00	150	
30	2,809	721,770	1.831	49.6	6.19	150	
300	28,090	7,217,697	18.307	496.2	61.86	150	
1000	93,633	24,058,989	61.023	1653.8	206.19	150	

pump2

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	ff3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.001	0.018	0.00	150	
30	2,809	721,770	1.831	49.6	6.19	150	
300	28,090	7,217,697	18.307	496.2	61.86	150	
1000	93,633	24,058,989	61.023	1653.8	206.19	150	

pump3

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	ff3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.001	0.018	0.00	150	
30	2,809	721,770	1.831	49.6	6.19	150	
300	28,090	7,217,697	18.307	496.2	61.86	150	
1000	93,633	24,058,989	61.023	1653.8	206.19	150	

pump4

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	ff3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	2.49E-05	0.001	0.00	85	
30	2,809	721,770	0.070	3.3	0.42	85	
300	28,090	7,217,697	0.699	33.4	4.17	85	
1000	93,633	24,058,989	2.330	111.4	13.89	85	

pump5

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	ff3/hr	flowrate gal/min	delta P psi	cost 1994\$
0.01068	1	257	0.000	0.001	0.00	85	
30	2,809	721,770	0.060	2.9	0.36	85	
300	28,090	7,217,697	0.597	28.5	3.56	85	
1000	93,633	24,058,989	1.989	95.1	11.86	85	

OFFCOMPR

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power hp	ff3/hr	flowrate gal/min	delta P psi	cost 1994\$	first stage power hp	second stage power hp	third stage power hp	fourth stage power hp	cost 1994\$	total cost
0.01068	1	257	0.024	0.024	0.02949	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	
30	2,809	721,770	67.2	67.2	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	\$89,300
300	28,090	7,217,697	671.6	671.6	828.4	828.4	828.4	828.4	828.4	828.4	828.4	828.4	\$476,400
1000	93,633	24,058,989	2238.8	2238.8	2761.2	2761.2	2761.2	2761.2	2761.2	2761.2	2761.2	2761.2	\$1,177,000
													\$350,300
													\$1,868,800
													\$4,617,100

SYNCOMPR

Wood feed bone dry tpd	Wood feed dried lb/hr	H ₂ produced scfd	1	257	721,770	7,217,697	24,068,989	0.01814000	51.0	509.6	1698.5	0.018	63900.0	340900.0	832200.0	0.01797	50.5	504.8	1682.6	63,800	\$340,500	\$841,300	0.01793	50.4	503.7	1678.8	\$63,700	\$340,000	\$839,800	\$255,700	\$1,364,300	\$3,360,500	
			cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	cost 1994\$	power hp	
0.01068																																	
30	2,809																																
300	28,090	7,217,697	509.6	509.6	\$342,900	340900.0	505.6	505.6	\$342,900	340900.0	504.8	504.8	340900.0	340900.0	504.8	504.8	340900.0	504.8	504.8	\$340,500	\$340,500	\$841,300	0.01793	50.4	503.7	1678.8	\$63,700	\$340,000	\$839,800	\$255,700	\$1,364,300	\$3,360,500	
1000	93,633	24,068,989	1698.5	1685.4	\$847,200	832200.0	1685.4	1682.6	\$847,200	832200.0	1682.6	1682.6	832200.0	832200.0	1682.6	1682.6	832200.0	1682.6	1682.6	\$841,300	\$841,300	\$841,300	0.01797	50.5	503.7	1678.8	\$63,800	\$340,500	\$839,800	\$255,700	\$1,364,300	\$3,360,500	

Heat Exchangers and Heaters

GSTMGEN

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	632.9	679,2815	192,0261	0,0049	
30	2,809	721,770	1.78E+06	679,2815	192,0261	13.6	\$1,200
300	28,090	7,217,697	1.78E+07	679,2815	192,0261	136.3	\$7,100
1000	93,633	24,058,989	5.93E+07	679,2815	192,0261	454.3	\$13,000

LTCOOL

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	365.5	326,6936	85,7387	0.0	
30	2,809	721,770	1.03E+06	326,6936	85,7387	36.7	\$1,300
300	28,090	7,217,697	1.03E+07	326,6936	85,7387	366.5	\$11,300
1000	93,633	24,058,989	3.42E+07	326,6936	85,7387	1221.8	\$26,600

PSACCOOL

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	967.7	120	85	0.1	
30	2,809	721,770	2.72E+06	120	85	266.5	\$9,300
300	28,090	7,217,697	2.72E+07	120	85	2665.0	\$51,600
1000	93,633	24,058,989	9.06E+07	120	85	8883.2	\$167,800

STMGEN6

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	485.3	38.57	149.67	0.1	
30	2,809	721,770	1.36E+06	38.57	149.67	236.1	\$8,700
300	28,090	7,217,697	1.36E+07	38.57	149.67	2361.4	\$46,300
1000	93,633	24,058,989	4.54E+07	38.57	149.67	7871.4	\$147,700

SYNCOOL1 / REFHR (MODEL1)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	27.1	1256.2968	149.6937	0.0	
30	2,809	721,770	7.61E+04	1256.2968	149.6937	0.4	\$1,000
300	28,090	7,217,697	7.61E+05	1256.2968	149.6937	4.0	\$1,100
1000	93,633	24,058,989	2.54E+06	1256.2968	149.6937	13.5	\$1,200

REFSTM / COMBCCOOL (MODEL2)

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatx1 duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	901.8	537.7543	186.5534	0.0090	
30	2,809	721,770	2.53E+06	537.7543	186.5534	25.3	\$1,300
300	28,090	7,217,697	2.53E+07	537.7543	186.5534	252.5	\$9,000
1000	93,633	24,058,989	8.44E+07	537.7543	186.5534	841.7	\$20,000

SYNCOMPR INTERSTAGE COOLERS

INTER1A FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatx1 duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	510	28.8	149.6937	0.1183	
30	2,809	721,770	1.43E+06	28.8	149.6937	332.3	\$11,100
300	28,090	7,217,697	1.43E+07	28.8	149.6937	3323.0	\$63,100
1000	93,633	24,058,989	4.78E+07	28.8	149.6937	11,076.51	\$206,400

**** cost of two identical heat exchangers

INTER1B FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	heatx1 duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	510	28.8	149.6937	0.1183	
30	2,809	721,770	1.43E+06	28.8	149.6937	332.3	\$11,100
300	28,090	7,217,697	1.43E+07	28.8	149.6937	3323.0	\$63,100
1000	93,633	24,058,989	4.78E+07	28.8	149.6937	11076.5	\$206,400

**** cost of two identical heat exchangers

INTERIC FLASH DRUM

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	H2 produced duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	257	510	28.8	149,6937	0,1183
30	2,809	721,770	721,770	1.43E+06	28.8	149,6937	332.3
300	28,090	7,217,697	7,217,697	1.43E+07	28.8	149,6937	3323.0
1000	93,633	24,058,989	24,058,989	4.78E+07	28.8	149,6937	11076.5

****cost of two identical heat exchangers

OFFCOMPR INTERSTAGE COOLERS

INTER2A

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	H2 produced duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	257	71	75.9471	19,3917	0.0482
30	2,809	721,770	721,770	1.99E+05	75.9471	19,3917	135.4
300	28,090	7,217,697	7,217,697	1.99E+06	75.9471	19,3917	1354.2
1000	93,633	24,058,989	24,058,989	6.65E+06	75.9471	19,3917	4514.0

INTER2B

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	H2 produced duty Btu/hr	delta Tlm °F	Avg U Btu/hr/sqft	area sqft	cost 1994\$
0.01068	1	257	257	60.3	58.4995	14,4888	0.0711
30	2,809	721,770	721,770	1.69E+05	58.4995	14,4888	199.8
300	28,090	7,217,697	7,217,697	1.69E+06	58.4995	14,4888	1998.4
1000	93,633	24,058,989	24,058,989	5.65E+06	58.4995	14,4888	6661.3

REACTORS

HTSHIFT
 SV (l/hr) = 4000
 height/diameter 2

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	flowrate acfh*	reactor volume ft3	diameter ft	height ft	pressure psl	cost 1994\$ S3316
0.01068	1	257	3.13	0.0008	0.08	0.16	504	\$6,700
30	2,809	721,770	8,804	2.20	1.12	2.24	504	\$26,700
300	28,090	7,217,697	88,039	22.01	2.41	4.82	504	\$56,200
1000	93,633	24,058,989	293,464	73.37	3.60	7.20	504	\$56,200

* acfh = actual cubic feet per hour

PRIMARY REFORMER

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	Heat duty MMBtu/hr	Chem Cost 1994\$	P&T, 3rd ed 1994\$	Chem Eng, Oct 10, 1977 1994\$	avg
0.01068	1	257	5.56E-04				\$53,600
30	2,809	721,770	1.562	\$53,600			\$331,300
300	28,090	7,217,697	15.620	\$328,600	\$329,500	\$335,800	\$926,933
1000	93,633	24,058,989	52.067	\$878,200	\$915,200	\$987,400	

Separation System

PSA SYSTEM
 Installed cost of PSA for 4.05 MMSCFD
 \$/SCFD 0.253

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	H2 produced cost \$
0.01068	1	257	
30	2,809	721,770	\$182,670
300	28,090	7,217,697	\$1,826,701
1000	93,633	24,058,989	\$6,089,003

Gasification (installed)
 cost of a 2200 bone dry ton/day gasification plant: \$12,440,143

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	gasifier plant cost 1994 K\$
0.01068	1	257	
30	2,809	721,770	\$615,339
300	28,090	7,217,697	\$3,084,000
1000	93,633	24,058,989	\$7,163,570

Capital Requirements

% of purchased equipment cost

- 18%
- 66%
- 11%
- 18%
- 10%
- 70%
- 6%
- 74%
- 42%

- Capital expense
- Instrumentation
- Planting
- Agricultural
- Buildings
- Land Improvements
- Service facilities
- Land
- Engineering and construction
- Contingencies

Equipment capital	Wood feed	H2 produced	uninstalled	Installation	other equipment	total equipment cost	total uninstalled
one dry tpd	dried lb/hr	scfd	capital	cost	installed	1994\$	capital
30	2,809	721,770	\$759,230	\$356,838	\$798,009	\$1,914,077	\$1,302,093
300	28,090	7,217,697	\$4,024,870	\$1,891,689	\$4,910,701	\$10,827,260	\$7,365,483
1000	93,633	24,058,989	\$10,261,213	\$4,822,770	\$13,252,573	\$28,336,557	\$19,276,569

Other fixed capital investment

Wood feed	H2 produced	Instrumentation	piping	electrical	buildings	yard	service facilities	land	engineering	contingencies	total related fixed
one dry tpd	dried lb/hr	scfd	capital	capital	capital	capital	capital	capital	capital	capital	capital
30	2,809	721,770	\$234,377	\$859,382	\$143,230	\$234,377	\$130,209	\$911,465	\$963,549	\$546,879	\$4,101,594
300	28,090	7,217,697	\$1,325,787	\$4,861,219	\$810,203	\$1,325,787	\$736,548	\$5,155,838	\$5,450,457	\$3,093,503	\$23,201,271
1000	93,633	24,058,989	\$3,469,782	\$12,722,536	\$2,120,423	\$3,469,782	\$1,927,657	\$13,493,598	\$14,264,661	\$8,096,159	\$60,721,193

Total fixed capital investment

Wood feed	H2 produced	fixed capital
one dry tpd	dried lb/hr	capital
30	2,809	\$6,015,671
300	28,090	\$34,028,531
1000	93,633	\$89,057,750

Working capital

Wood feed	H2 produced	working capital
one dry tpd	dried lb/hr	capital
30	2,809	\$1,082,821
300	28,090	\$6,125,136
1000	93,633	\$16,030,395

18% of the capital expenditures estimated so far.

Operating costs

electricity cost 0.05 \$/kWh
 on-line factor 0.9

Electricity

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	power require hp	cost \$/yr
0.01068	1	257	0.188	
30	2,809	721,770	527.391	\$155,044
300	28,090	7,217,697	5273.907	\$1,550,440
1000	93,633	24,058,989	17579.690	\$5,168,134

Water

for gasification 0.45 lb/lb bdw
 for reforming 0.64 lb/lb bdw
 for steam generation 2.97 lb/lb bdw
 BFW cost \$0.33 \$/1000 liters

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	for gasification 1000 liters/year	for reforming 1000 liters/year	for steam generation 1000 liters/year	total BFW 1000 liters/year
30	2,809	721,770	2.01	2.86	13.29	18.16
300	28,090	7,217,697	20.09	28.63	132.89	181.61
1000	93,633	24,058,989	66.95	95.43	442.97	605.35

Operating costs of PSA

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	op cost \$/1000 SCF	cost \$/yr
30	2,809	721,770	\$6.50	\$4,692
300	28,090	7,217,697	\$6.50	\$46,915
1000	93,633	24,058,989	\$6.50	\$156,383

labor	Wood feed dried lb/hr	H2 produced scfd	personnel and their cost per year			total labor cost \$/yr
			operators	formen	supervisors	
30	2,809	721,770	\$28,700	3	\$30,500	\$39,300
300	28,090	7,217,697		6		\$155,900
1000	93,633	24,058,989		8		\$272,500
						\$329,900

byproduct credit: steam

00 psig steam							
steam stream6	0.2838	lb/lb dried wood					
total	0.2838						
Wood feed							
one dry tpd	dried lb/hr	H2 produced	steam produced	steam produced	selling price	yearly revenue	
30	2,809	scfd	lb/hr	1000 kg/year	\$/1000 kg	\$	
300	28,090	721,770	797	3,167.62	\$7.88	\$24,960.83	
1000	93,633	7,217,697	7,972	31,676.18	\$7.88	\$249,608.27	
		24,058,989	26,573	105,587.26	\$7.88	\$832,027.57	

00 psig steam						
stream stream1a (3)	1.1253	lb/lb dried wood				
stream stream2a	0.056499	lb/lb dried wood				
stream stream2b	0.048249	lb/lb dried wood				
stream stream4	0.378					
stream stream5	0.754	lb/lb dried wood				
total	2.362048					

Wood feed bone dry tpd	Wood feed dried lb/hr	H2 produced scfd	steam produced lb/hr	steam produced 1000 kg/year	selling price \$/1000 kg	yearly revenue \$
30	2,809	721,770	6,635	26,363.87	\$5.18	\$136,564.82
300	28,090	7,217,697	66,350	263,638.65	\$5.18	\$1,365,648.22
1000	93,633	24,058,989	221,166	878,795.51	\$5.18	\$4,552,160.74