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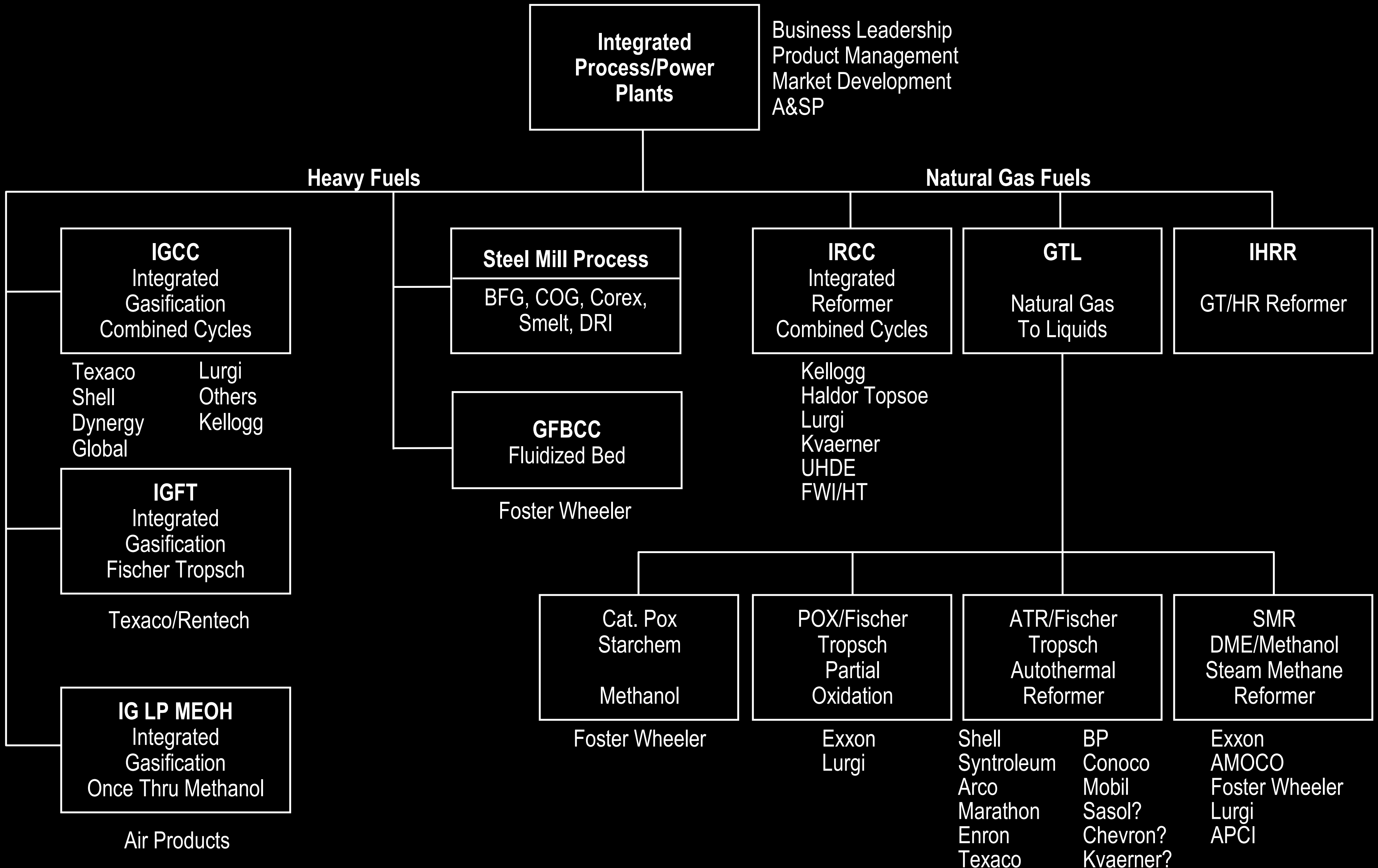
Hydrogen Workshop

Douglas M. Todd
GE Schenectady, NY
September 19, 2000

Process Power Plants



Process Power Plants Examples

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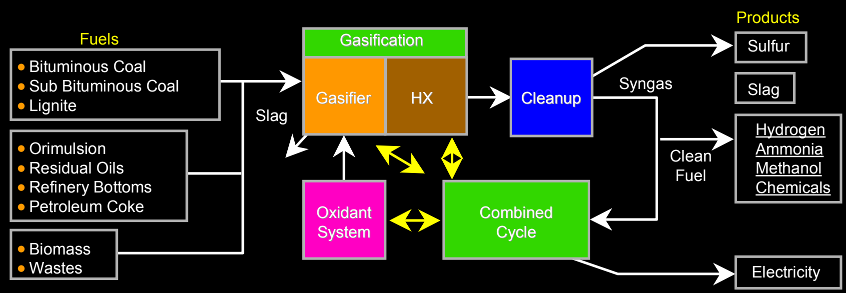

Clean Power From Heavy Fuels

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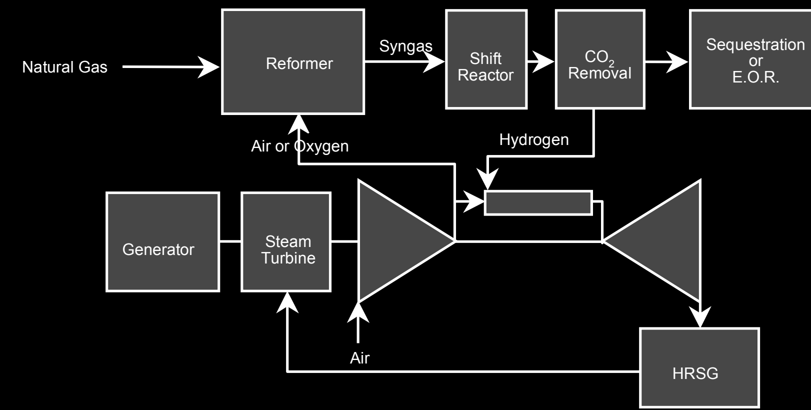
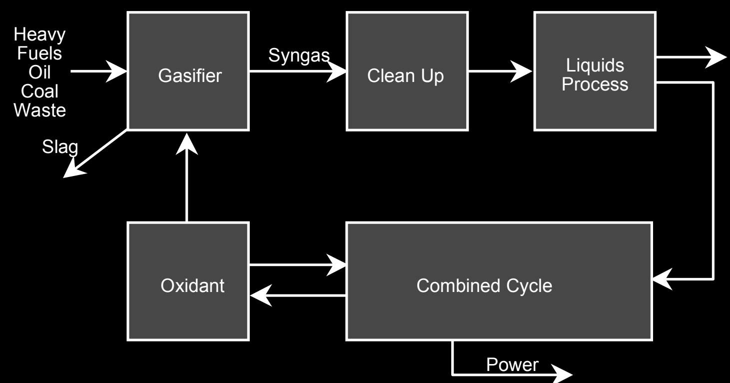


CO_2 Reduction

IGFT / Methanol



Enhanced IGCC Economics

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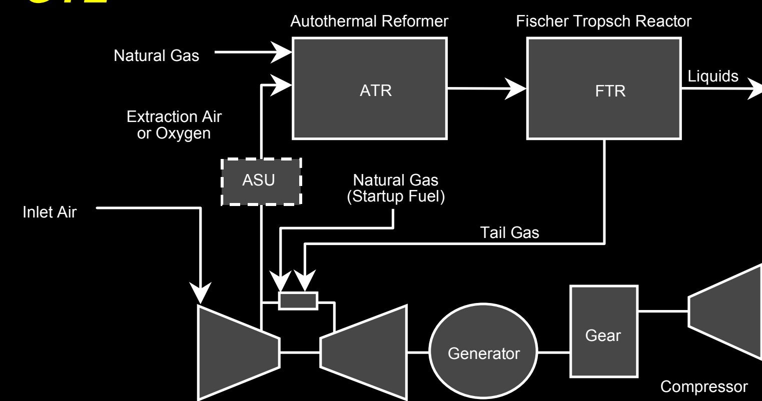

Monetizing Remote Gas

GT 20452wA

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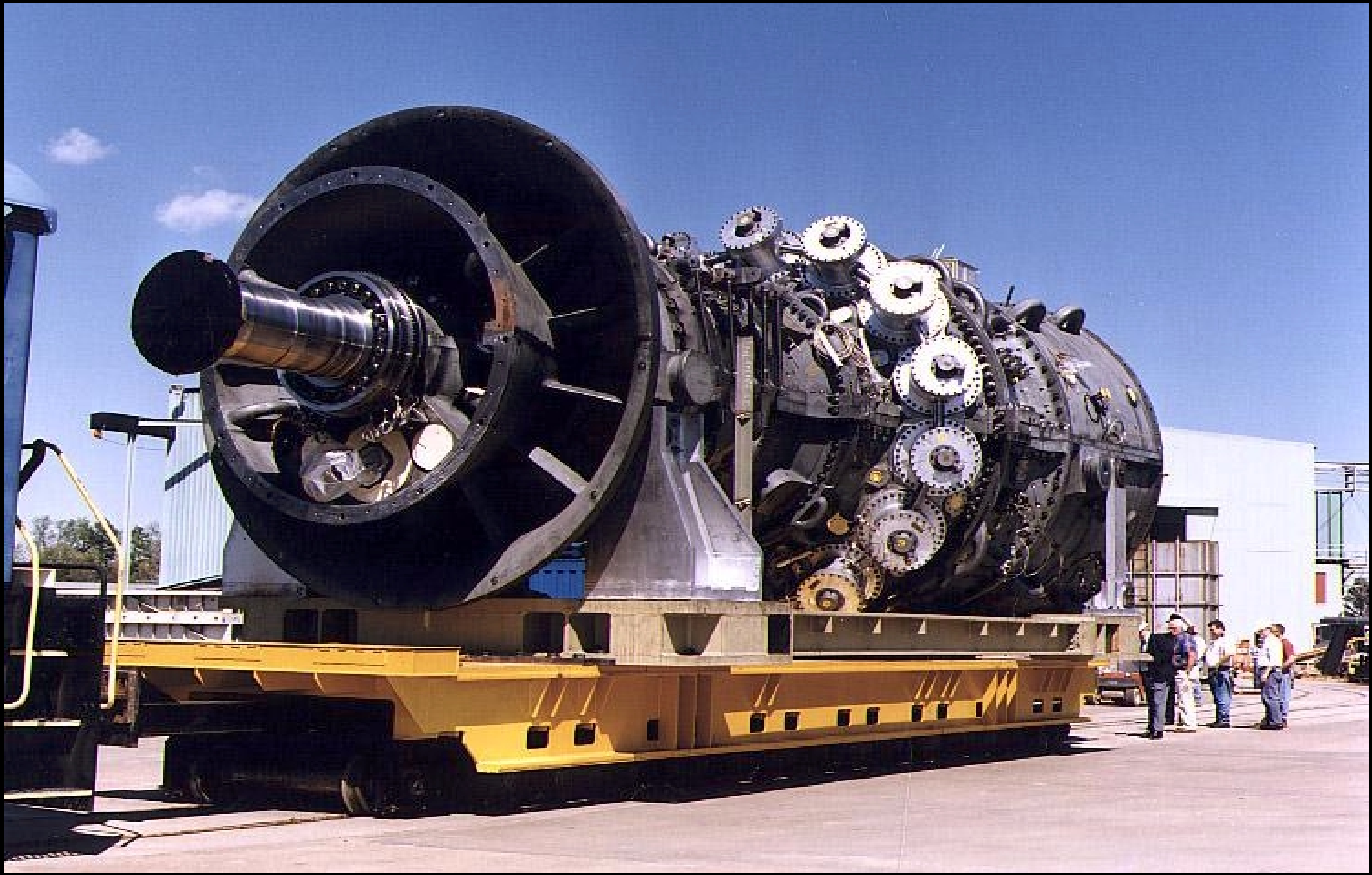
GE’s MS9001H Gas Turbine



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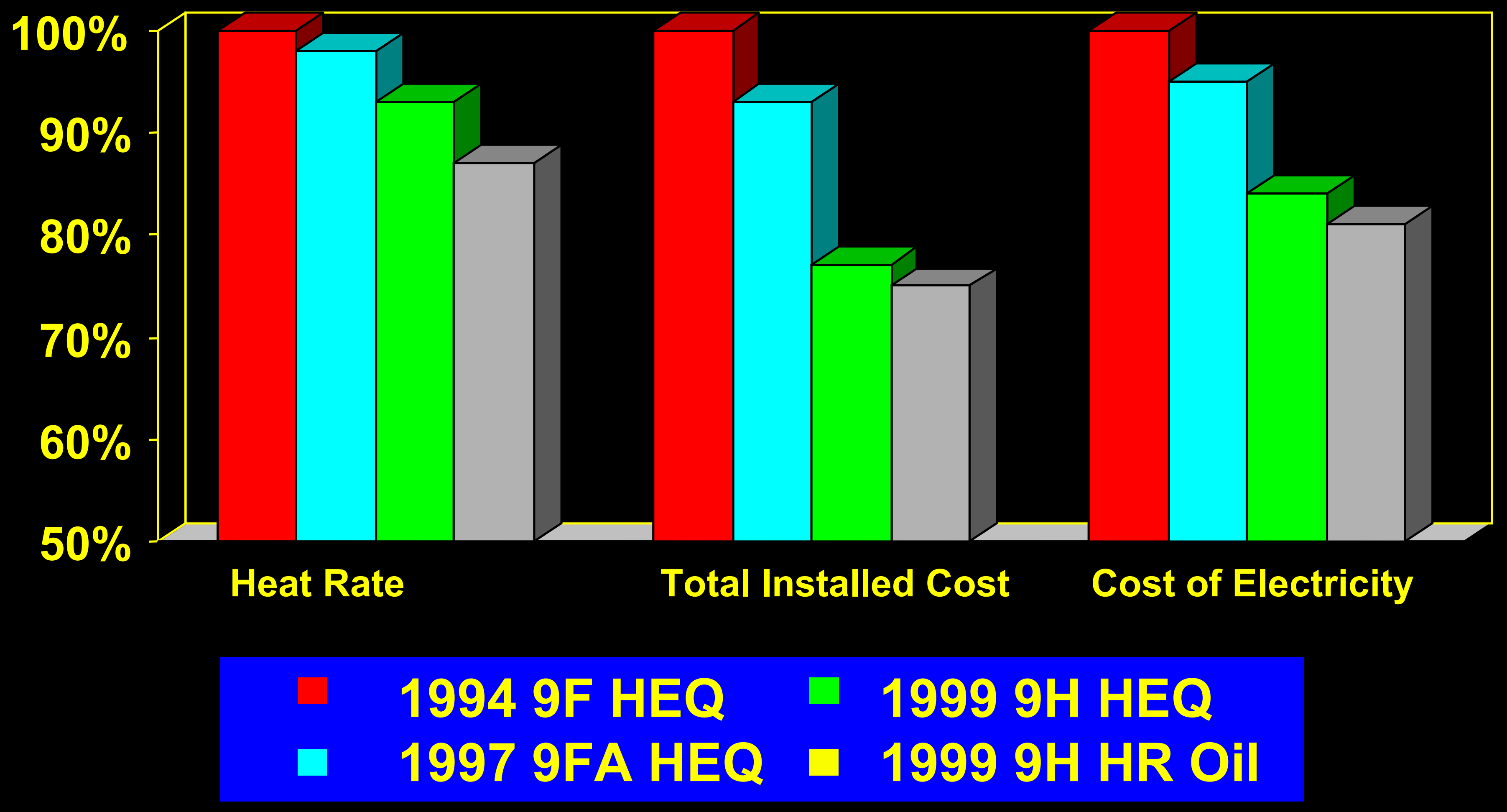
Economic Impact of HEQ IGCC Design Study Improvements



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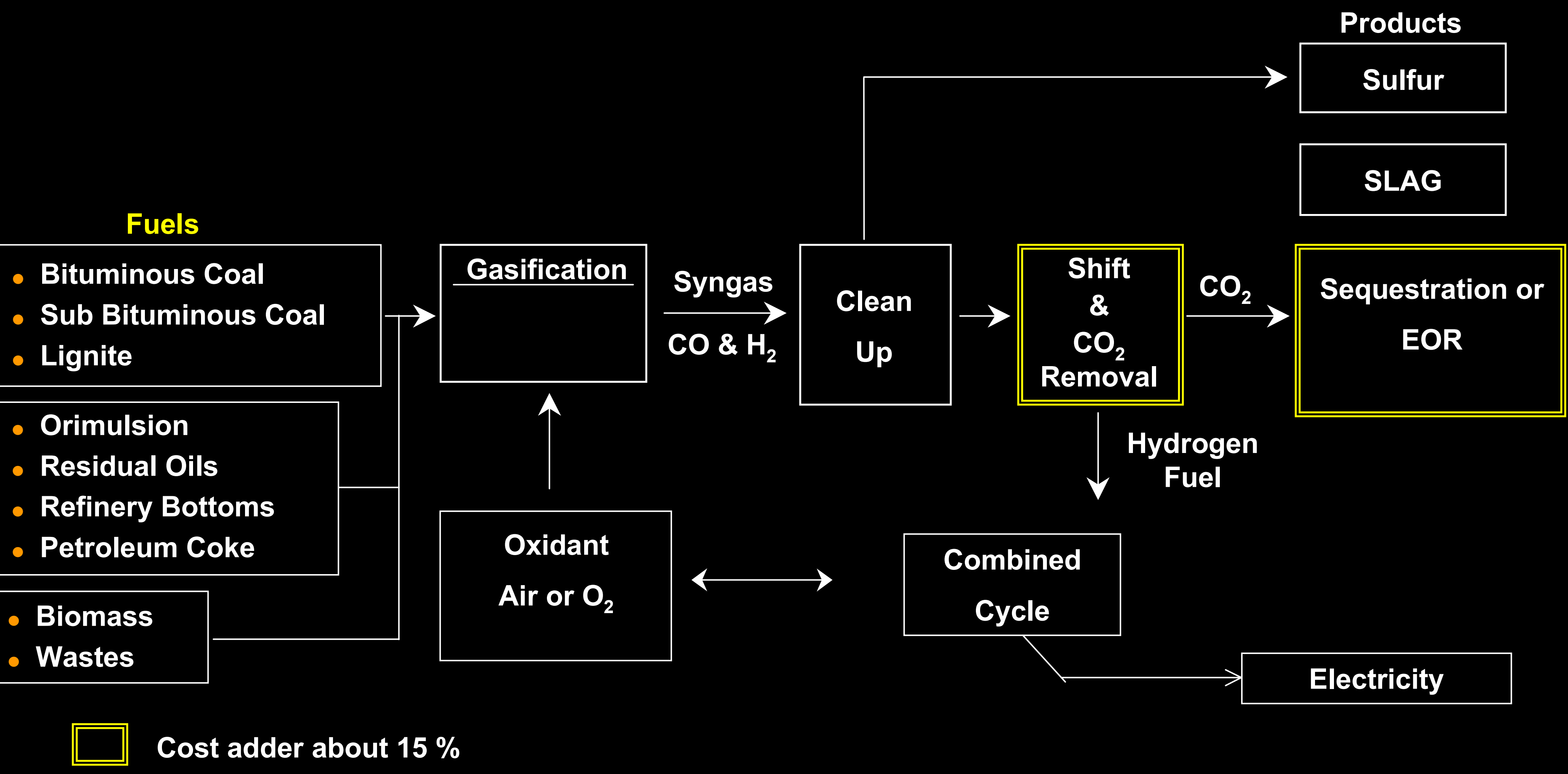

CO_2 Emission Reduction for Heavy Fuel Power Plants

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IGCC Penetration

Customer	C.O. Date	MW	Application	Gasifier
SCE Cool Water - USA	**1984**	**120**	**Power/Coal**	**Texaco - O_2**
LGTI - USA	1987	160	Cogen/Coal	Destec - O_2
Demkolec - Netherlands	1994	250	Power/Coal	Shell - O_2
PSI/Destec - USA	**1995**	**260**	**Repower/Coal**	**Destec - O_2**
Tampa Electric - USA	**1996**	**260**	**Power/Coal**	**Texaco - O_2**
Texaco El Dorado - USA	**1996**	**40**	**Cogen/Pet Coke**	**Texaco - O_2**
SUV - Czech.	**1996**	**350**	**Cogen/Coal**	**ZUV - O_2**
Schwarze Pumpe - Germany	**1996**	**40**	**Power/Methanol/Lignite**	**Noell - O_2**
Shell Pernis - Netherlands	**1997**	**120**	**Cogen/H_2/Oil**	**Shell - O_2**
Puertollano - Spain	1998	320	Power/Coal/Pet Coke	Prenflow - O_2
Sierra Pacific - USA	**1998**	**100**	**Power/Coal**	**KRW - Air**
ISAB - Italy	1999	500	Power/H_2/Oil	Texaco - O_2
API - Italy	2000	250	Power/H_2/Oil	Texaco - O_2
MOTIVA - Delaware	**2000**	**240**	**Repower/Pet Coke**	**Texaco - O_2**
Sarlux/Enron - Italy	**2000**	**550**	**Cogen/H_2/Oil**	**Texaco - O_2**
EXXON - Singapore	**2002**	**180**	**Cogen/H_2/Oil**	**BGL - O_2**
Bio Electrica - Italy	**2000**	**180**	**Power/Biomass**	**Texaco - O_2**
FIFE - Scotland	**2000**	**12**	**Power/H_2/Cogen/Oil**	**Lurgi - Air**
EDF - Total	**2003**	**400**	**Power/Sludge**	**Texaco - O_2**
FIFE Electric - Scotland	**2003**	**400**	**Power/Coal/RDF**	**BGL - O_2**
Nihon Sekiyu - Japan	2004	350	Power/Oil	Texaco - O_2
IOC Paradip	**2004**	**180**	**Power/Pet Coke**	**Shell - 0_2**
CONFIDENTIAL	**2004**	**750**	**Power/Pet Coke**	**Texaco - 0_2**
PIEMSA	**2004**	**800**	**Power/H_2/Oil**	**Texaco - 0_2**
		6752		

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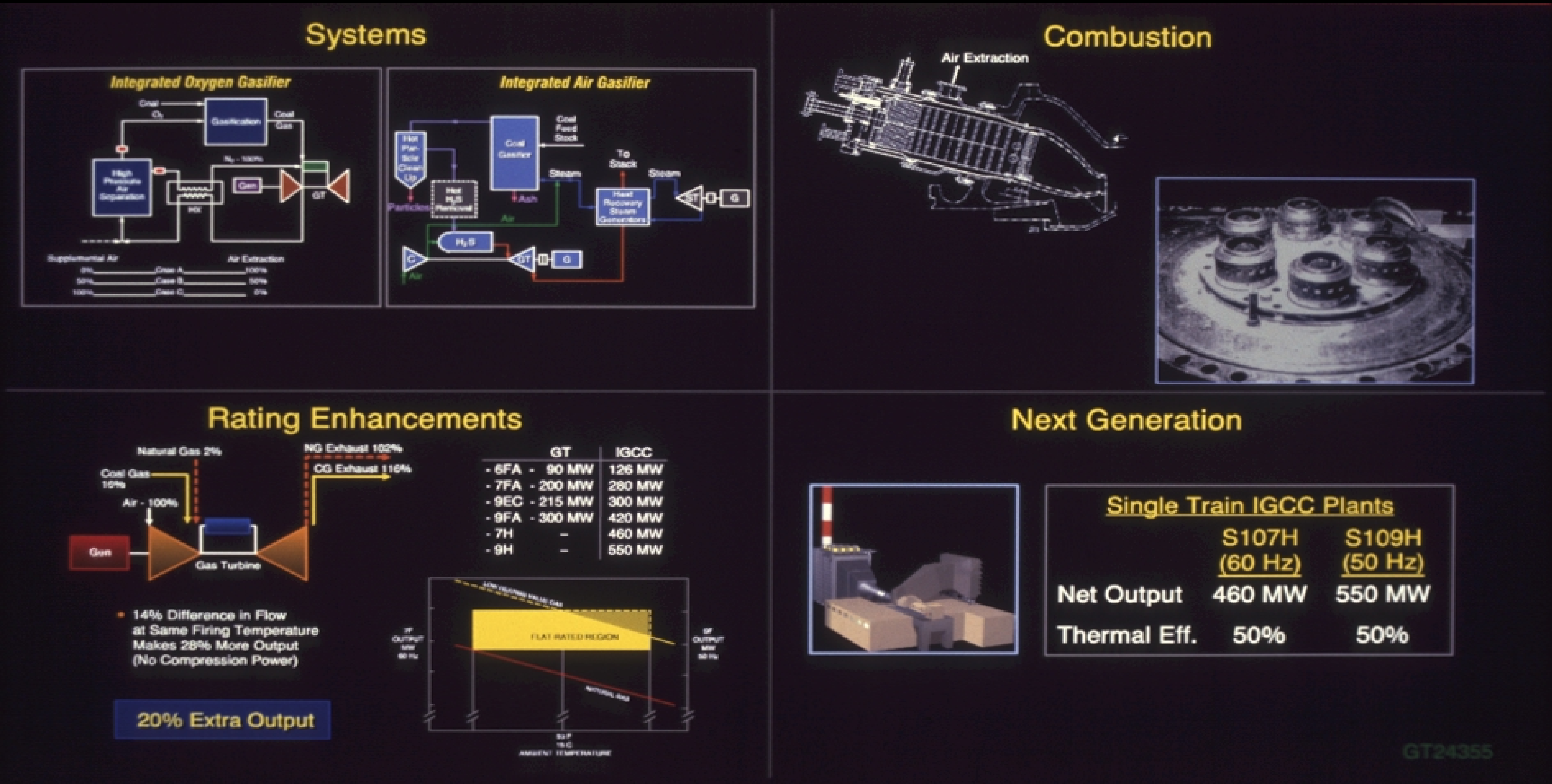
GE IGCC Development Program



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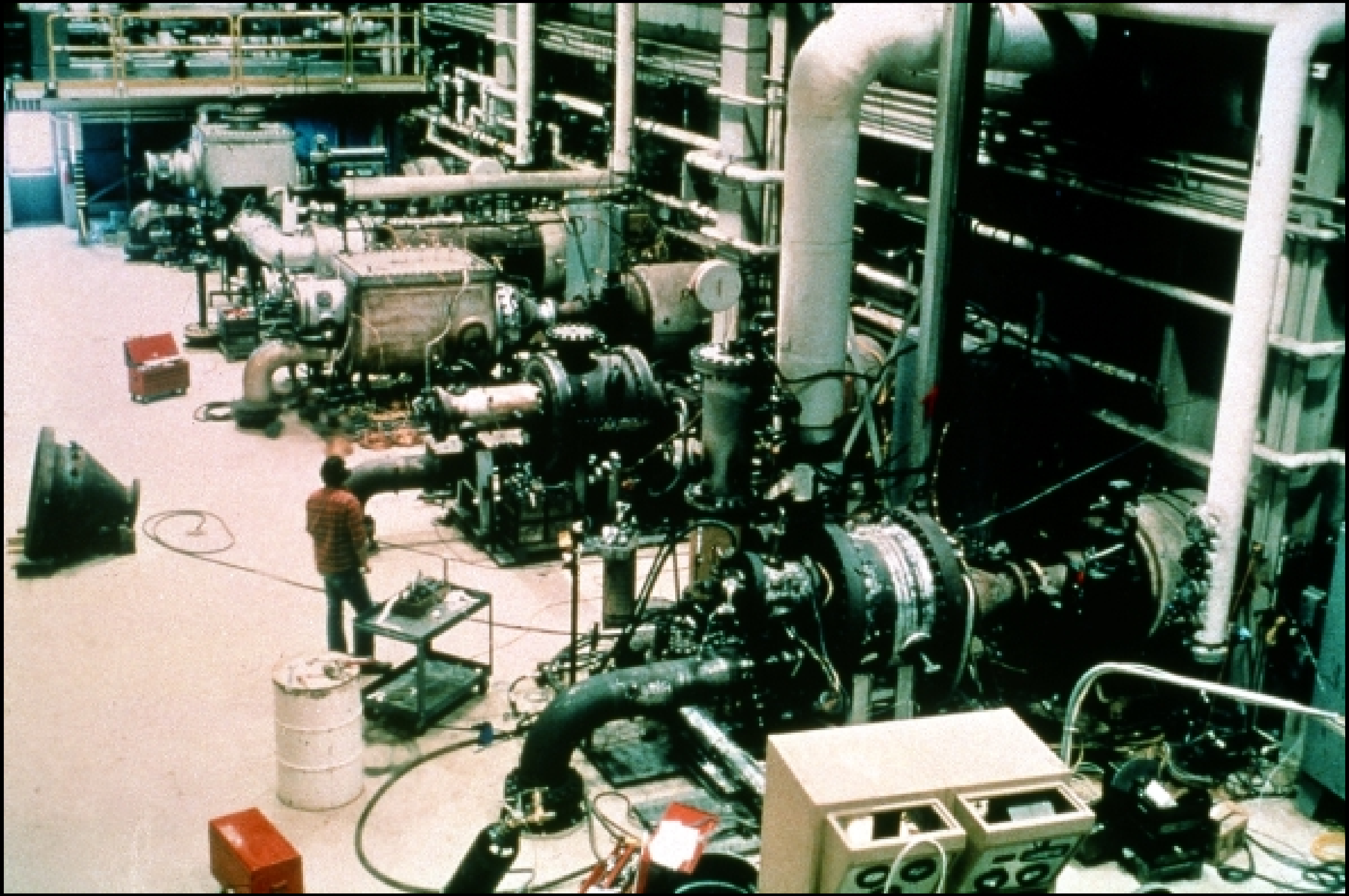
GE PGE Combustion Laboratory



Syngas Comparison

Syngas	PSI	Tampa	El Dorado	Pernis	Sierra Pacific	ILVA	Schwarze Pumpe	Sarlux	Fife	Exxon Singapore	Motiva Delaware	Confidential	PIEMSA	Tonghua
H_2	24.8	37.2	35.4	34.4	14.5	8.6	61.9	22.7	34.4	44.5	32.0	33.34	42.3	10.3
CO	39.5	46.6	45.0	35.1	23.6	26.2	26.2	30.6	55.4	35.4	49.5	42.44	47.77	22.3
CH_4	1.5	0.1	0.0	0.3	1.3	8.2	6.9	0.2	5.1	0.5	0.1	0.06	0.08	3.8
CO_2	9.3	13.3	17.1	30.0	5.6	14.0	2.8	5.6	1.6	17.9	15.8	17.76	8.01	14.5
N_2 + AR	2.3	2.5	2.1	0.2	49.3	42.5	1.8	1.1	3.1	1.4	2.15	5.72	2.05	48.2
H_2O	22.7	0.3	0.4	--	5.7	--	--	39.8	--	0.1	0.44	0.08	0.15	0.9
LHV, - Btu/ft^3	209	253	242	210	128	183	317	163	319	241	248	230.4	270.4	134.6
- kJ/m^3	8224	9962	9528	8274	5024	7191	12,492	6403	12,568	9,477	9,768	9,079	10,655	5304
T_{fuel} F/C	570/300	700/371	250/121	200/98	1000/538	400/204	100/38	392/200	100/38	350/177	570/299	300/149	338/170	-
H_2/CO Ratio	.63	.80	.79	.98	.61	.33	2.36	.74	.62	1.26	.65	.79	.89	.46
Diluent	Steam	N_2	N_2/Steam	Steam	Steam	--	Steam	Moisture	H_2O	Steam	H_2O/N_2	N_2 / H_2O	N_2	n/a
Equivalent LHV														
- Btu/ft^3	150	118	113*	198	110	--	200	--	*	116	150	115.3	129	134.6
- kJ/m^3	5910	4649	4452	7801	4334	--	7880	--	--	4600	5910	4543	5083	5304

* Always co-fired with 50% natural gas

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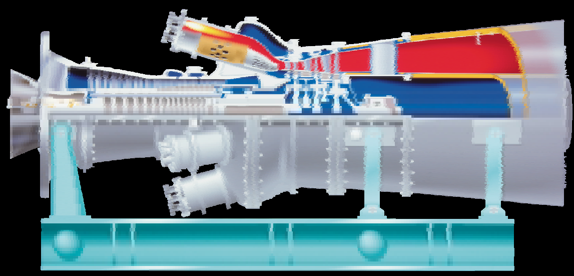
Combustion Technology Development

IGCC



MOTIVA - First Pet Coke Appli. With 9 ppm NO_x

Exxon - 1st St. Cracker Bottoms With 25% Wobbe Var.

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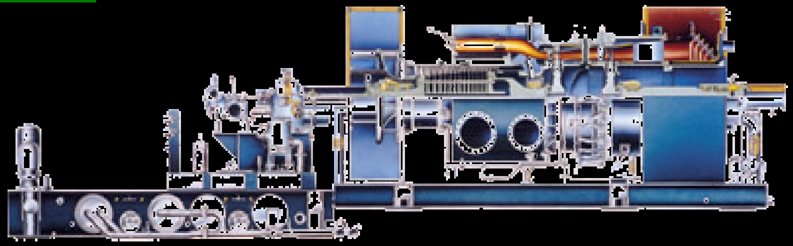
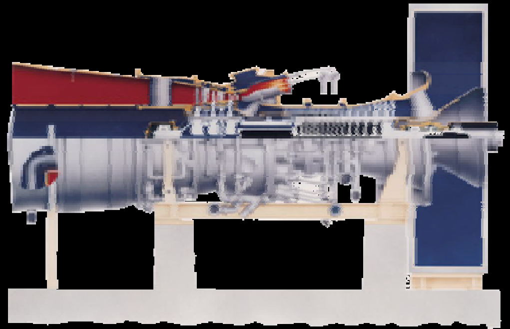


Air - First Air-Blown Tail Gas

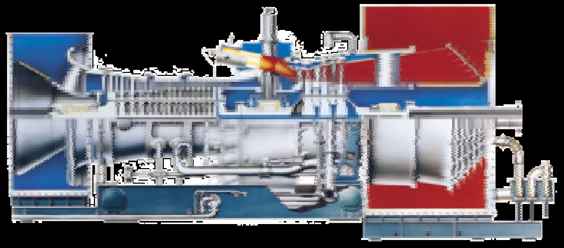
Oxygen - Variety of Syngas

IRCC



Hydrogen Combustion for Reduction of CO_2

Steel



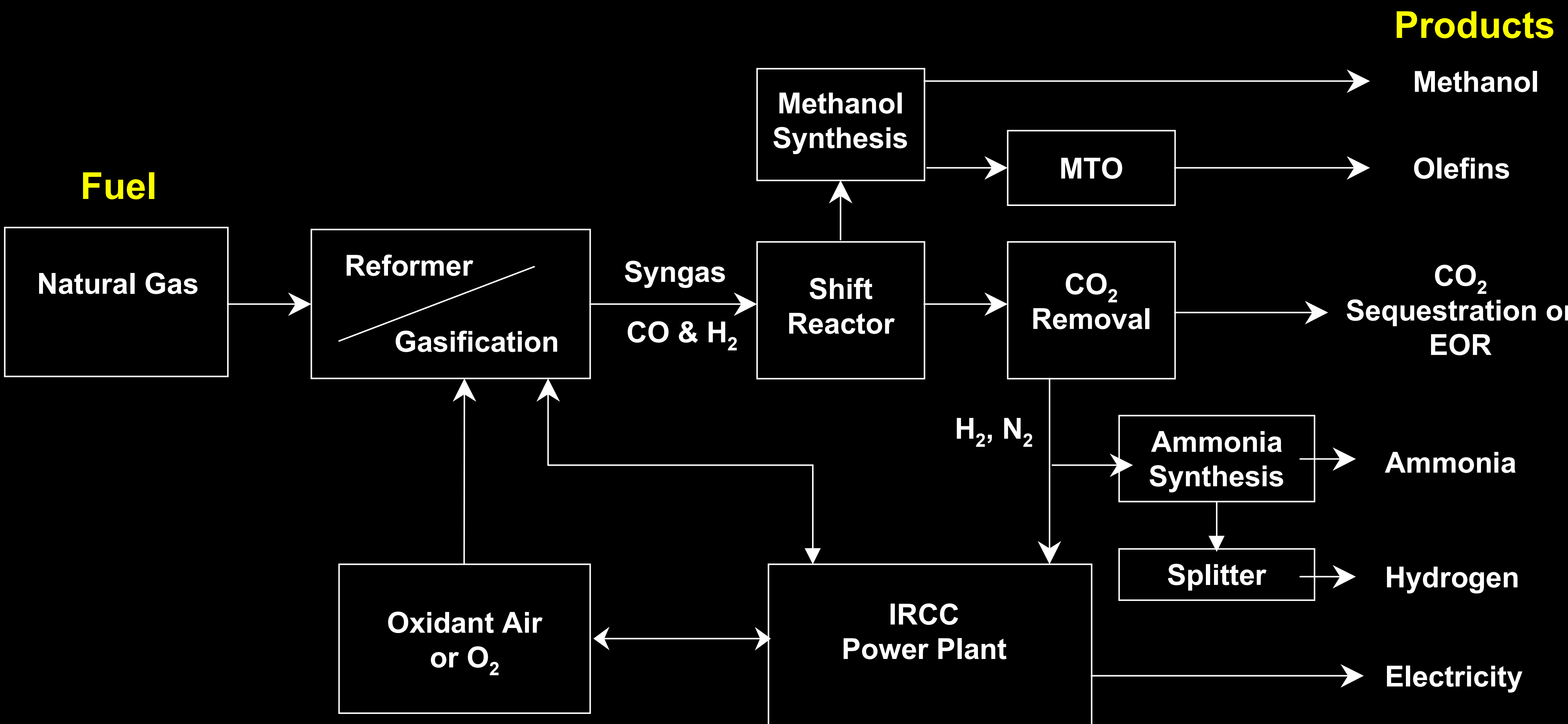
Mixtures of BFG, COG, Nat. Gas

Shell-Pernis Coproduction Plant

- 1650 t/d Vacuum Residue
- 2 x 6B Gas Turbines
- Shell/Lurgi Gasifier
- 255 t/d Hydrogen
- 115 MW Power
- Steam to Refinery
- Operation 1997

RDC 27963

IRCC Electricity Coproduction



Multiple Products and Electricity with CO_2 Emmision Reduction from Natural Gas

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Combustion Test Objectives

- Evaluate Operability and Emissions of the GE IGCC Multi-Nozzle Combustor burning IRCC High H_2 Fuel
- Evaluate Component Metal Temperatures Throughout the Load Range
- Determine Sensitivity of Major Performance Parameters to Variations in Hydrogen Content

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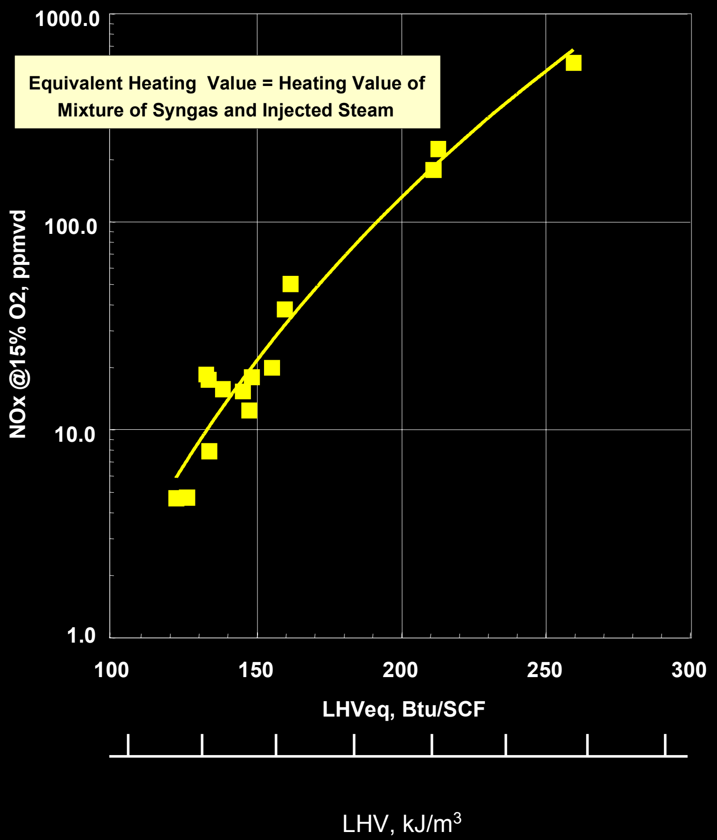
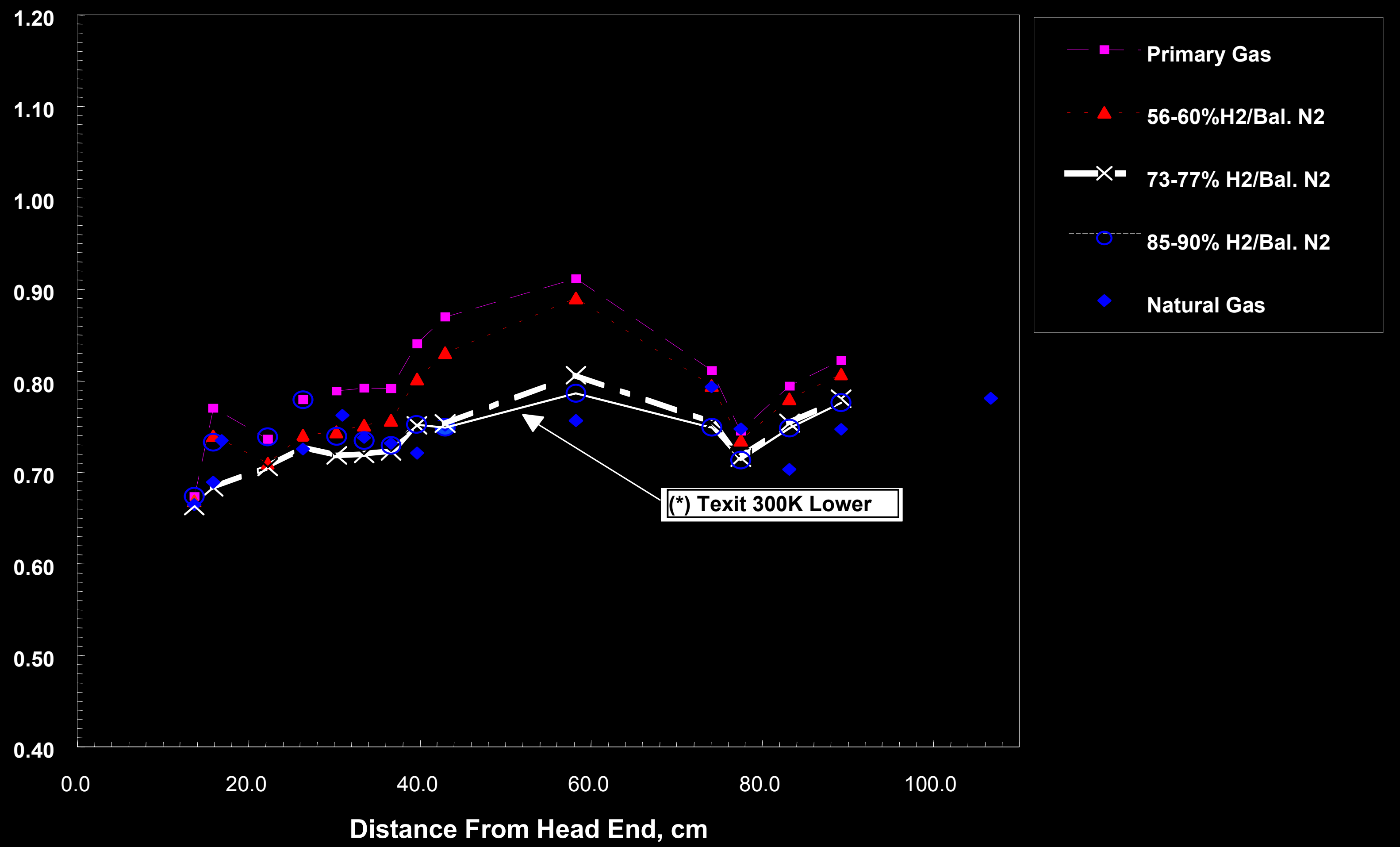
NOx vs Equivalent Calorific Value for Several Fuel Compositions

Video Capture of Flame Structure - 85-90% H_2



50 - 95% H_2 By Volume, Bal. N_2, $N_2 + H_20$

Combustor Metal Temperatures at 210º from TDC - Inline with Fuel Nozzles



Effect of Fuel Composition on Axial Metal Temperature Distribution at 210^0 from TDC

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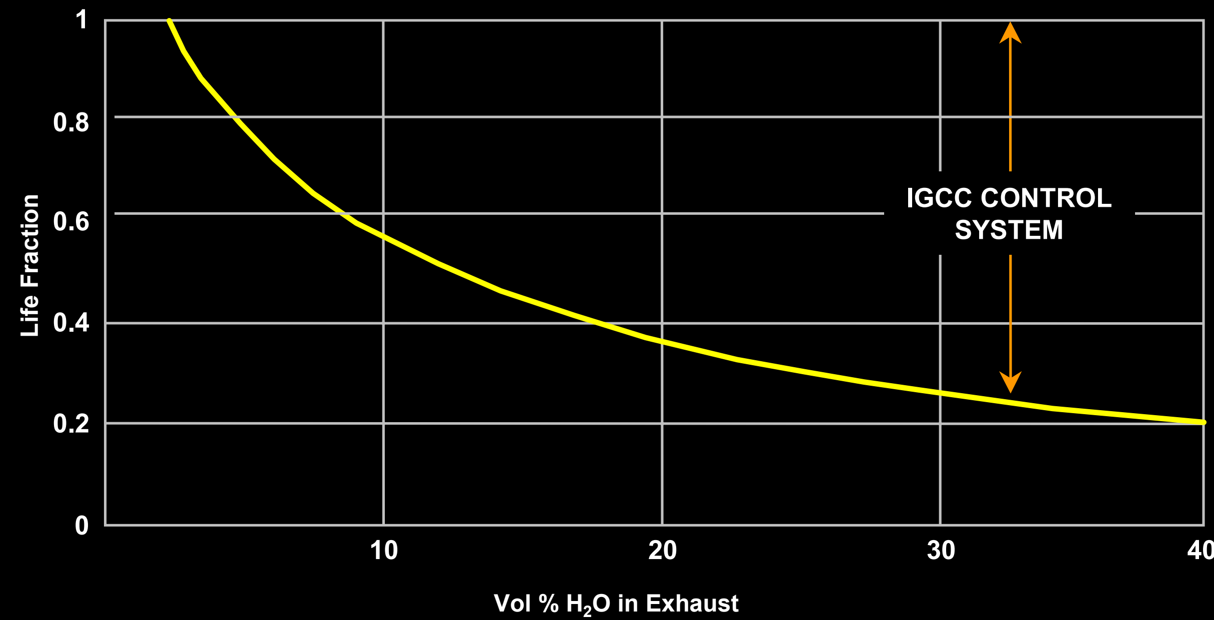
Syngas - Reliability / Availability / Maintenance

Syngas Combined Cycle Can Have Same Performance as Natural Gas Combined Cycle

- Need Automatic Fuel Switch/Nitrogen Purge
- Need Clean Syngas
- Reduced Firing Temp to Maintain Design Metal Temp/ 100% Life



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Conclusions

- Hydrogen is an acceptable fuel for GE Gas Turbines using IGCC Combustors
- NOx Emissions Below 10 ppmvd @15% O_2
- No Adverse Effects on Combustion Parts Lives
- Reliability, Availability and Maintainability Equivalent to NG
- Integration of a Hydrogen Fueled Gas Turbine with Process Plants is Technically Feasible to Reduce CO_2 Emissions by 90%
- Optimization Required to Improve Cost of Electricity