Engine vs. Turbine

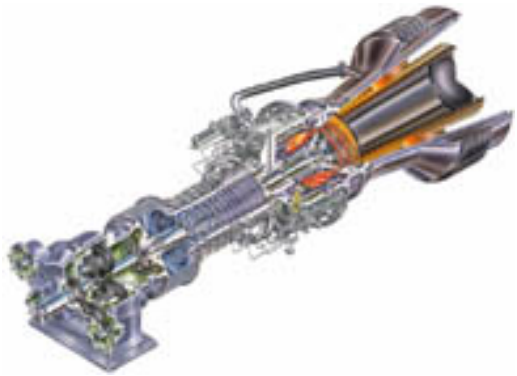
The Ultimate Confrontation

Presentation to the
Ministry of Mines and Industries
July 13, 2005

Fair Comparison

- Engine: Caterpillar GCM34

- Turbine: GE LM2500, combined cycle



- Both are recent technology, widely used
- Considered “best in class”
- Cost data from Gas Turbine World, May 2005

Logistics, Delivery

Generation Unit Options		Gas Engine	Simple Cycle	Combined Cycle
Manufacturer		Caterpillar	GE	GE
Type		Recip Gas	LM2500	LM2500
Model		GCM34		
Delivery FOB	months	13	11	14
Transport	months	1	1	1
Installation	months	4	1	16
	months	18	13	31
Largest item dimensions				
Package Length	m	12.3	14.0	
Package Width	m	3.1	3.3	
Package Height	m	4.8	3.3	
Approximate Weight	tonnes	132.7	73.7	

- Advantage: Turbine

Capital Costs ($000)

Capital Costs ($000)		Engines	Turbines	
Gas Engines		58,600	-	
Electrical, controls		3,186	-	
Gas Turbines		-	44,000	
Steam Generation HRSG & Turbine		-	55,200	
Compressor		-	3,000	
Civil works		8,500	8,500	
Demineralization, extra wells & pumps		-	4,000	
Spare parts, tools & equipment		2,450	2,450	
Interconnection		2,665	2,665	
Contingency	15%	11,310	17,972	
Security	5%/year	6,503	17,798	
Engineering, project management, start-up		14,000	18,000	
Owners' cost, training, insurance		2,800	2,800	
TOTAL PROJECT CONSTRUCTION COSTS		110,014	176,385	* No IDC
Power Capacity - SITE CONDITIONS (MW)		102.3	108.2	
Installed Cost per kW ($/kW)		$ 1,075	$ 1,630	

- Advantage: Engine

Operation and Maintenance ($000)

Gas Price	4.50	4.50
Operating Expenses	Engines	Turbines
Gas	30,321	29,796
Operation and Maintenance	10,595	8,582
Water Cost	-	1,904
Compressor O&M	-	140
TOTAL ANNUAL OPERATING EXPENSES	40,916	40,422
Energy Production (MWH)	847,595	858,164
Operating Cost - ¢/kWh	4.83	4.71

- Advantage: Turbine

Lifetime Cost per kWh

Cost per kWh build-up	Engines	Turbines
Capital cost to build - lifetime ($000)	110,014	184,825
Financing charge, 20-year, 10% blended rate	12,922	21,710
Financing cost per energy production - ¢/kWh	1.52	2.53
Adding capital & operating components		
Capital Cost per kWh - ¢/kWh	1.52	2.53
Operating Cost - ¢/kWh	4.83	4.71
Total lifetime cost per kWh - ¢/kWh	**6.35**	**7.24**

- Advantage: Engine

Project IRR, NPV

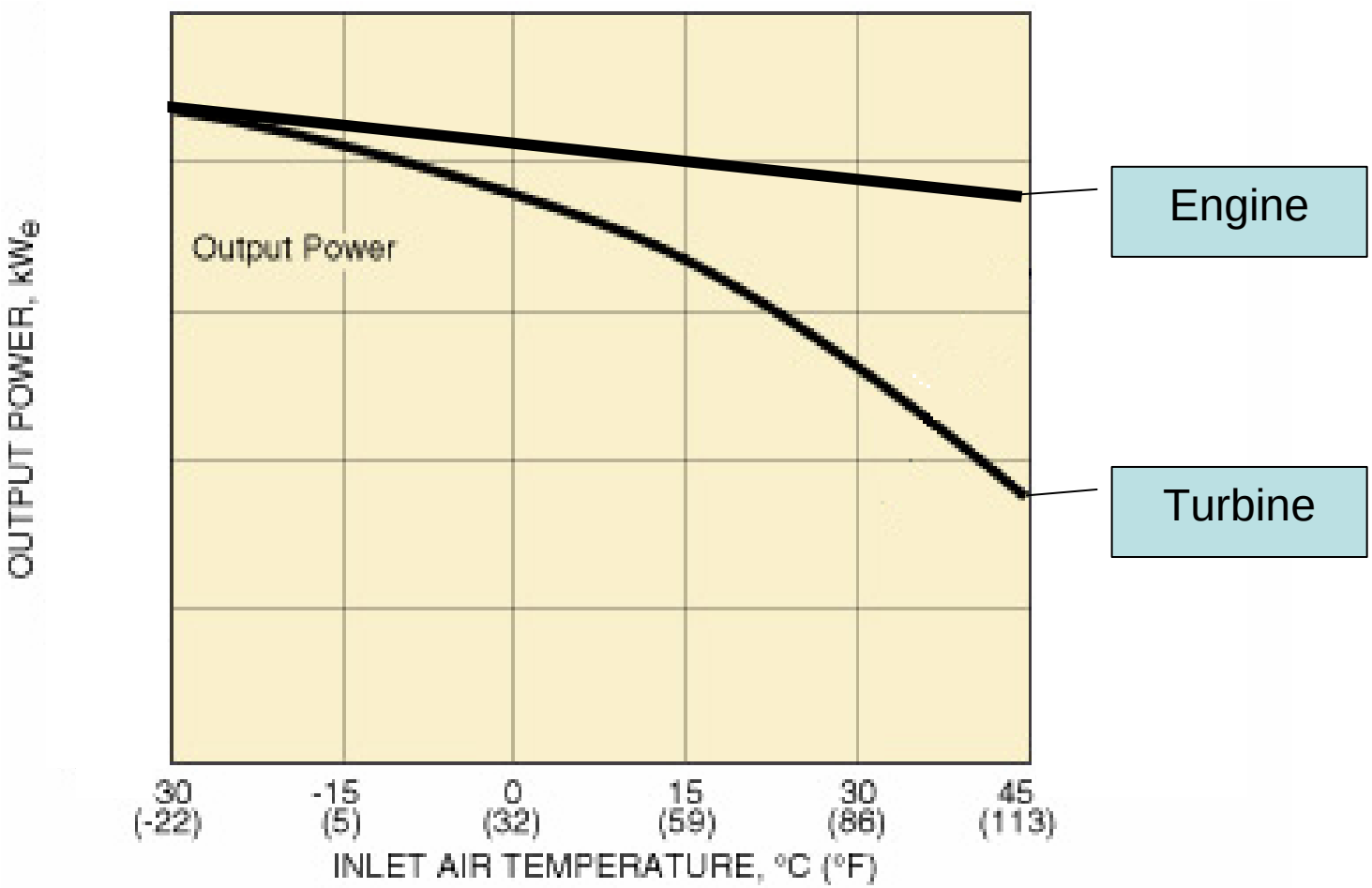
NPV & IRR Calculation (000's)		Engines	Turbines
One-time investment		110,014	184,825
Revenues at	8 ¢/kWh	67,808	68,653
Expenses		40,916	40,422
Annual Profit		26,891	28,231
IRR - 20 year, pre-tax basis		23.7%	13.8%
NPV - 20 yr pre-tax	10% Disc. Rate	$224,281	$235,031

- Advantage: Engine

Effect of Sheberghan Location

Adjusting for site conditions	Engines	Turbines
Power Capacity - MW nameplate, ISO	**105.1**	**124.0**
Derating due to temperature	0.4%	3.3%
Derating due to altitude	0.0%	5.0%
Performance degradation	0.5%	2.0%
Parasitic load	1.8%	1.5%
Gas compressor parasitic load	0.0%	1.0%
Power Capacity - SITE CONDITIONS (MW)	**102.3**	**108.1**
Heat Rate, (kJ/kWh) nameplate at ISO	**8273**	**6810**
Derating due to temperature	0.4%	3.3%
Derating due to altitude	0.0%	5.0%
Performance degradation	0.5%	2.0%
Parasitic load	1.0%	2.0%
Gas compressor parasitic load	0.0%	1.0%
Heat Rate at Site - before adjustments	**8430**	**7716**
Waste heat to amine benefit	-481	0
Net heat rate SITE CONDITIONS (kJ/kWh)	**7950**	**7716**

LM2500 Turbine vs. GCM34 Engine



Turbine loses output significantly in high temperatures.