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Gas to Power Feasibility Study

Final Report

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IDB Improving lives

Objective of the Study

The objective of the study is to perform a comprehensive technical and economic assessment of gas to power generation options

- The study addresses technical, economic, and financial aspects of gas-fired power generation options
- The study does not represent an update to the Expansion Study. The sole purpose of demand and supply analysis sections of the report is to confirm that capacity that can be generated by the new gas fired power plant is needed
- The core of the study is not impacted by demand and supply items not related to determining that the capacity generated by the new gas fired power plant is needed

Main questions answered by the study

Natural Gas Supply and Demand	Electricity Supply and Demand	Cost-Benefit analysis of Options	Climate benefits
• Available quantity of natural gas? • How much power can be generated?	• What is Guyana's projected electricity demand? • What are the requirements for power generation? • Supply/Demand analysis for different generation options	• Technical and commercial analysis of the options • What are the two best options	• Existing emission profile • Emissions reductions and climate benefits for the different options

Interim Report - I

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Main questions answered by the study

Technical assessment of Options	***Cost estimate and financial analysis***	***Grid Impact Analysis***	***Implementation Plan***
• Conceptual design of the two options • Defining design characteristics like size, gas req, land, and no. of engines • Heat & material balances for the options	• Develop cost estimates for the different options • Analysis of different project financing options • Financial analysis of the project and calculate required tariff • Calculate lifetime costs and LCOE for options	• Analysis of power evac. to the grid • Analysis for different power injection scenarios • CAPEX investment requirements	• Recommend preferred option and project structure for implementation • Estimate total time to completion

Interim Report - II

Both Interim Report I and II have been reviewed by the GoG stakeholders

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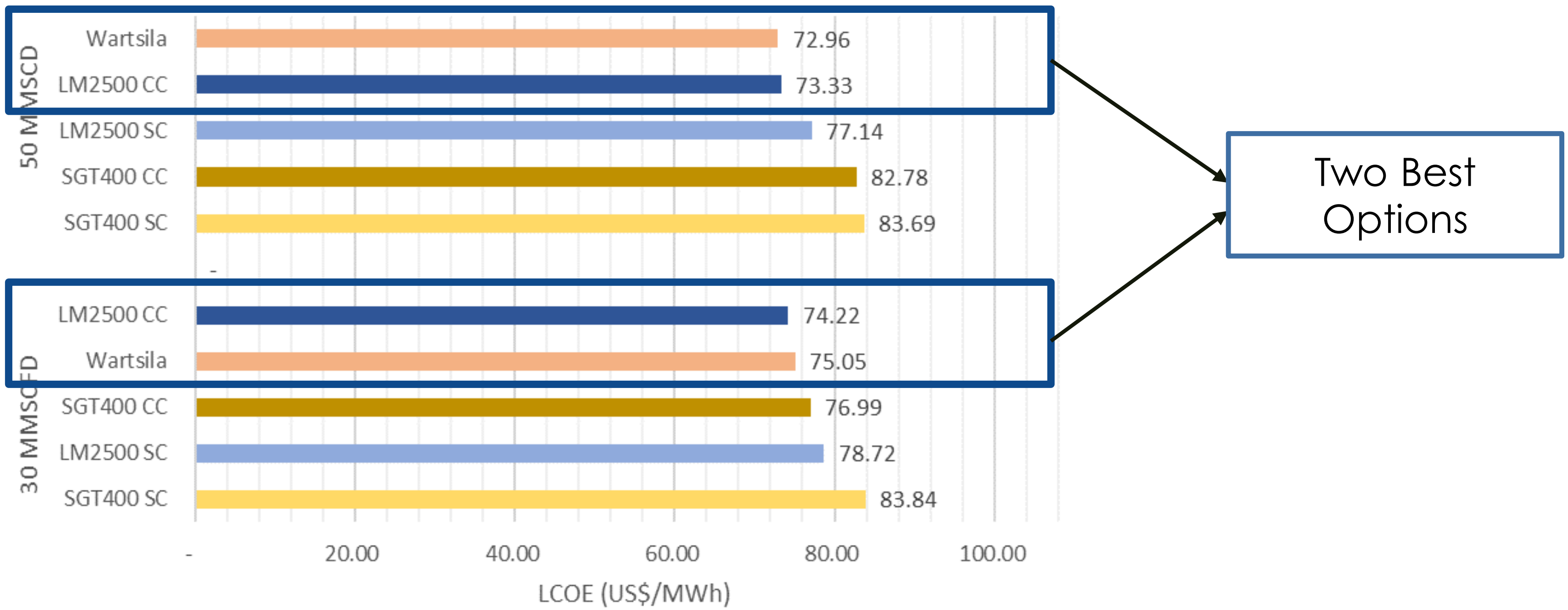
Option Comparison Results

- The technological options under consideration are:
  - Dual Fuel Reciprocating Engines (analyzed based on Wartsila technology)
  - Combined Cycle (analyzed based on GE LM2500 and Siemens SGT400)
  - Simple Cycle (analyzed based on LM2500 and SGT400)



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Comparison between the two best options

LM 2500 CC	Wartsila Reciprocating Engines
Pros	
Efficient utilization of Natural Gas	Lower upfront capital costs
Highest possible capacity for all options	GPL and Guyana's familiarity with the technology.
	Lower unit size of 17 MW. Lower reserve requirements
	HFO as an alternate fuel
	Stable heat rate over entire load range
Cons	
Large unit size of 30 MW. Higher reserve requirements	Higher heat rate at full load
Higher upfront capital costs	Lower capacity for the 30 MMscfd scenario
In case of interruption in the Natural Gas Supply, the LM 2500 CC would need the significantly more expensive LFO for operation	In case of interruption in the Natural Gas Supply, RICE is able to operated on HFO, which is much less expensive than LFO
Higher heat rate increase at partial load operation	

The option economics is similar, but using reciprocating engines seem to present lower risk due to ability to operate on less expensive HFO

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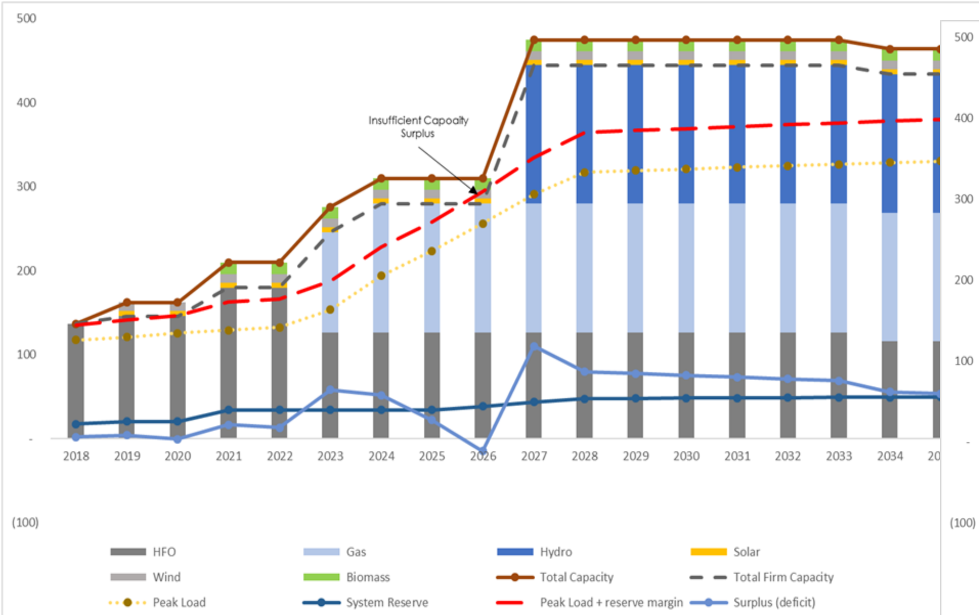
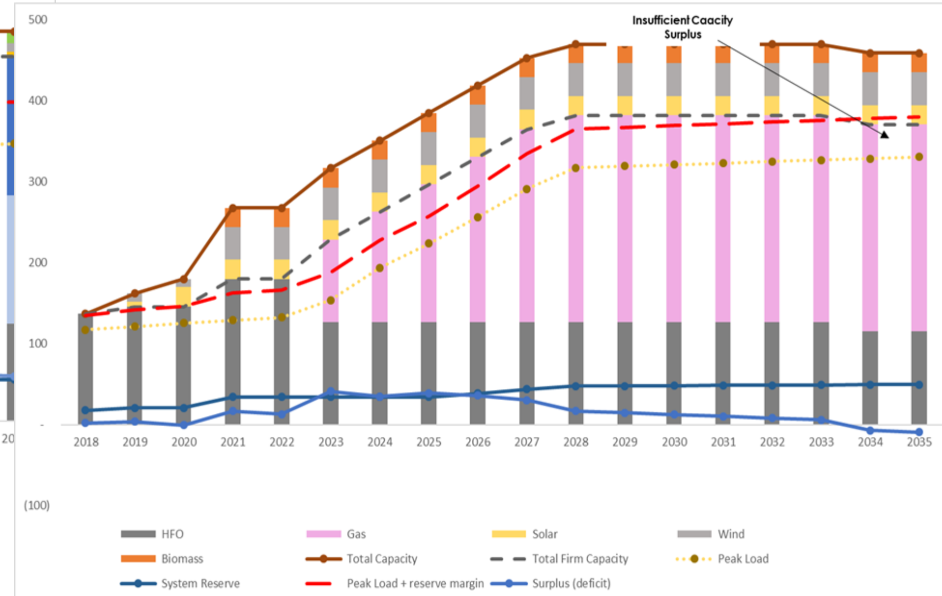
Expansion plan for the two gas supply scenarios

- Analysis is based on 2018 Expansion Study provided by MPI to K&M
- The scope of the analysis was to estimate capacity and generation by the new gas fired power plant, not to modify or update the Expansion Study
- The required firm capacity for Guyana increases to 258 MW by 2025 and 380 MW by 2035.
- The estimated power capacity from the available gas is:
  - 30 MMscfd – between 153 MW to 180 MW
  - 50 MMscfd – between 255 MW to 300 MW
- Prices of natural gas, solar, and hydro power for economic analysis are taken from the Expansion Study

Expansion plan for the two gas supply scenarios





- For scenario with gas supply limited to 30 MMscfd hydro is included for base load operation as per the Expansion Study
- Though hydro is a renewable source, it requires additional environmental and financials studies to confirm its viability against natural gas
- There will be insufficient firm capacity by 2026 under 30 MMscfd scenario. Additional gas quantities to support higher gas-based capacity, additional HFO units, or renewable-based firm capacity will have to be added by 2026.

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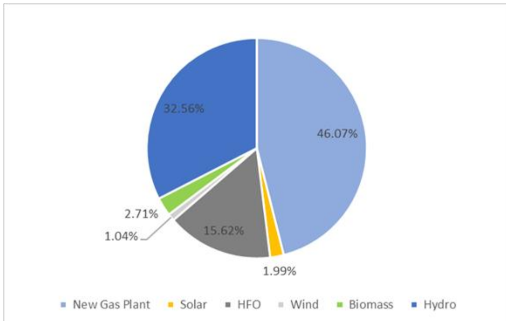
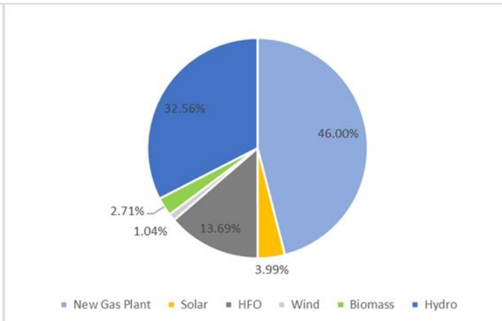
Generation mix in 2035

30 MW Solar



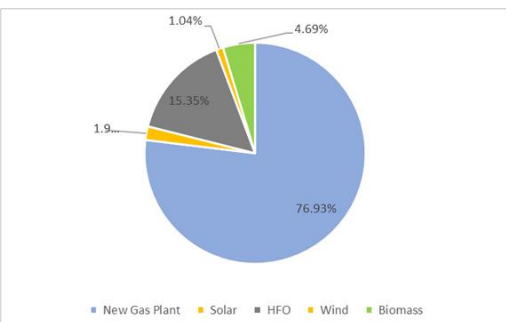
60 MW Solar



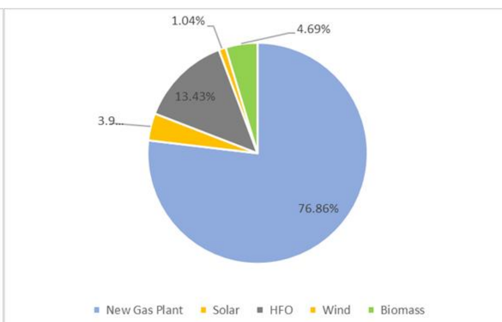
30 MMscfd

- Hydro and Gas provide baseload power by providing 83% of total generation
- Flexibility of gas can provide buffer in case of variation in hydro resource

30 MW Solar



60 MW Solar



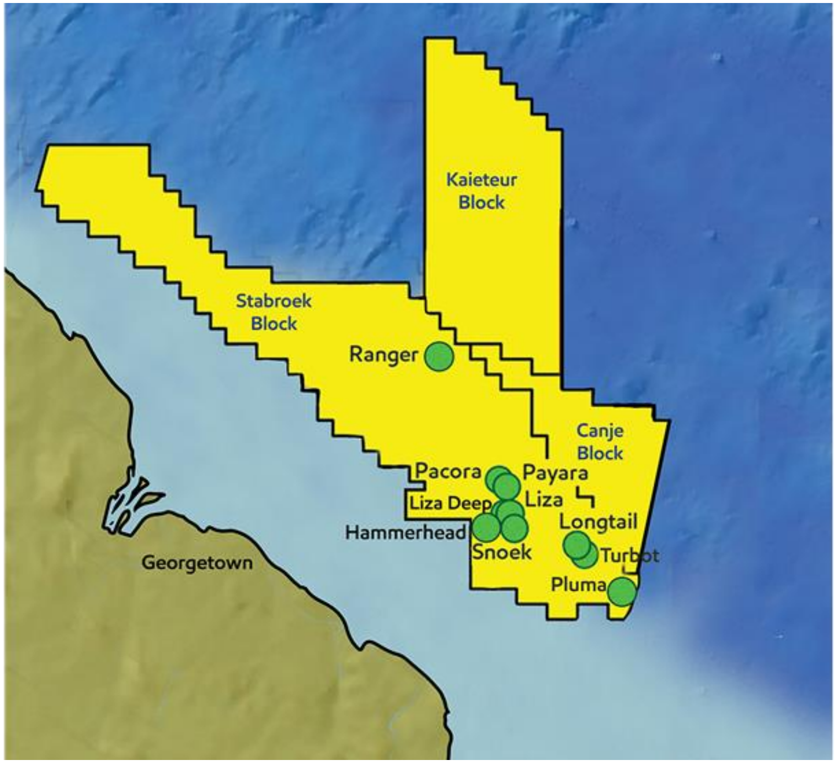
50 MMscfd

- Natural gas is the primary source of electricity providing 77% of generation
- Backup fuel will be use in case of natural gas supply interruption

Expansion Study assumed 6 MW solar penetration. K&M understands that this no longer the case. Thus, K&M also modeled 30 MW and 60 MW solar. No impact on gas generation. Increase in solar reduces HFO generation.

Gas Reserves and Supply Scenarios

- According to MPI, gas would be supplied from the offshore Stabroek Oil Block, Lisa 1 field
- According to the Expansion Study, the total quantity of recoverable oil reserves in Lisa-1 field is estimated at 450 million barrels, while gas reserves available for power generation are estimated at 0.2 Tcf
- The total quantity recoverable oil reserves in Stabroek block is currently estimated at over 4 billion barrels
- The study considers two gas supply scenarios – 30 MMscfd and 50 MMscfd
- 0.2 Tcf is sufficient to supply 30 MMscfd for approximately 18 years and 50 MMscfd for approximately 11 years



Stabroek Oil Field Development

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Gas Reserves and Supply Scenarios (cont-d)

- There are no reliable numbers on Stabroek block gas reserves; however, based on the information on recent additional oil and gas discoveries, it is likely that recoverable gas reserves are higher than presented in the Expansion Study
- Not all the gas reserves can be recovered due to possible technical difficulties and distance between the fields within the Stabroek block

Though it is likely that available natural gas reserves are sufficient to supply a 250 to 300 MW power plant for the period of its useful life, GoG needs to obtain firmer estimate on gas reserves available for power generation from potential gas supplier

Viability of Conversion of Existing Plants NG

- Conversion is not economically viable when taking into consideration both the conversion cost and the cost of gas supply pipeline
- Running the pipeline from the off-shore gas line landing point to the existing power plants located in densely populated areas is highly problematic
- Other gas delivery options such as LNG or CNG delivered in containers by truck is challenging given the existing road infrastructure

Emission Benefits

- The total GHG emissions reduction for a period between 2023 and 2035 are estimated at approximately 8.7 Million tonnes (55%) for the 30 MMscfd , and 6.1 Million tonnes for the 50 MMscfd (39%).

- Significant reduction of SOx and NOx contaminant emissions.

- The economic benefit due to reduction in emissions for a period between 2023 and 2035 is estimated, between approximately US$150 and US$234 million due to greenhouse and between approximately US$70 and US$80 million due to NOx and SOx emission reduction.

Plant Conceptual Design and Capital Cost

Summary of Key Characteristics of Generating Alternatives

Parameter	Units	RICE 30 MMscfd	RICE 50 MMscfd	LM2500 CC 30 MMscfd	LM2500 CC 50 MMscfd
Number of engines	No.	9	15	6	10
Net Plant Output	MW	152.5	254.2	182.6	304.3
Full Load Heat Rate	Btu/kWh	7724	7724	6780	6780
Full Load Efficiency	% (LHV)	44.2%	44.2%	50.3%	50.3%
Daily Gas Demand	Scfd	28.6	47.5	30.0	49.9
Total EPC Capital Cost	million USD	152	239	246	393.5
Total IPP Owner Capital Cost	million USD	164	261	268	429

- CC efficiencies are higher than RICE
- RICE option CAPEX are lower than CC
- Total CAPEX for EPC option is lower than for IPP

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Grid Impact Analysis and Capital Cost

The Study considered three options for power evacuation from the new gas-fired power plant:

- Evacuation at 69 kV level to Good Hope and New Sophia Substations
- Evacuation at 230 kV level to New Sophia Substation
- Evacuation at 69 kV level to Good Hope and at 230 kV level to New Sophia Substations

Summary of Grid CAPEX Investment Scenarios (USD)

Evacuation System Buildout Voltage Level	180 MW (30 MMscfd	30 MW (50 MMscfd)
69 kV Only	53,352,000	93,872,000
230 kV Only	89,000,000	90,366,000
69kV and 230 kV	77,900,000	84,672,000

Combination of 69 kV and 230 kV is a recommended option. It provides flexibility for connecting to Arco Norte network and has the least cost for the 50 MMscfd scenario

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Financing Options

- **Corporate financing:** GPL corporate financing such as long-term balance sheet financing (corporate loan or bond) with project constructed on an EPC basis
  - Developed, constructed, owned and operated by GPL
  - Financed by a loan taken by GoG or GPL

- **Project Financing (IPP):** Project is financed by a private investor on a non-recourse basis
  - Privately developed, constructed, operated, and owned;
  - Have a significant proportion of private finance on a non-recourse or limited recourse basis; and
  - Have long-term power purchase agreements with GPL

Financing Options

	Pros	Cons
Corporate Financing	• Lower capital cost and resulting electricity cost • GPL owns and controls the assets	• GPL would have to raise financing • GPL is fully exposed to project development, schedule, performance, and operation risk
Project financing	• Project Sponsor takes all project development, financing, construction, schedule, performance, and operation risks • Potentially, more efficient operation and better maintenance practices	• Higher electricity cost to GPL

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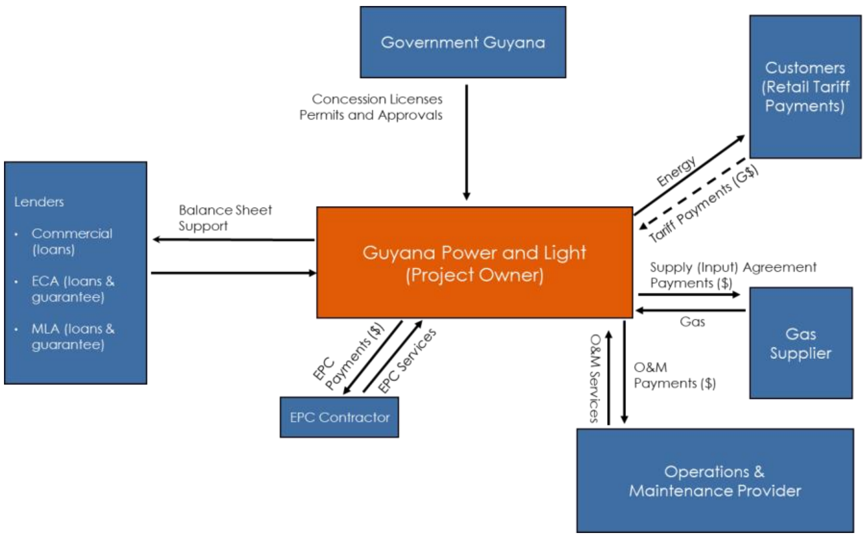
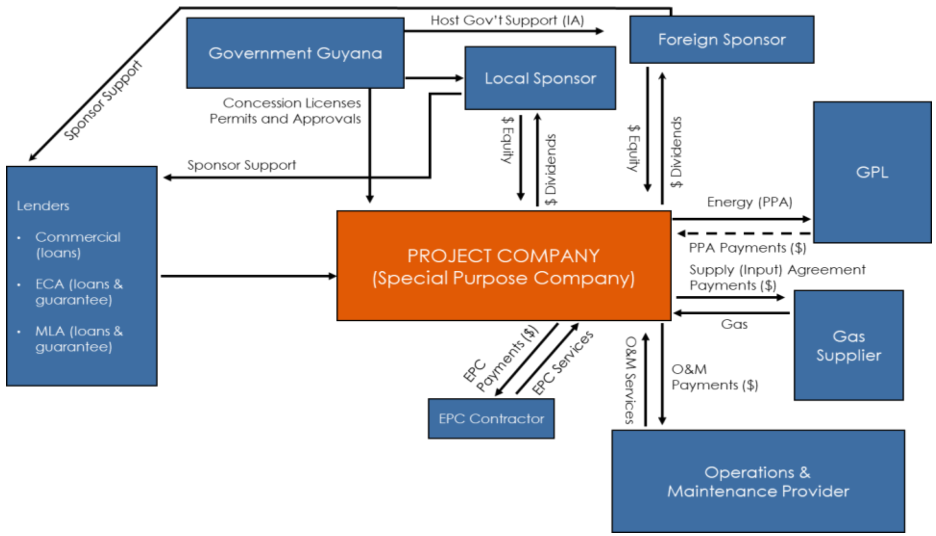
Financing Options (cont-d)

Typical EPC structure



Typical IPP Structure



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EPC versus IPP

- Best international practice is to select an EPC Contractor or IPP Sponsor via international competitive bidding
- Non-solicited sole source proposal may result in selection of a potentially non-qualified contractor or project sponsor and/or non-competitive price

Item	EPC versus IPP	Advantage
Size	Corporate finance is suitable for smaller projects whereas project finance is best suited for large projects as IPP developers typically have easier access to equity	IPP
Transaction Costs	IPP Projects have higher transaction costs. Legal, lender, advisory, are all higher.	EPC
Time to Financial Closing	Corporate finance transactions can be arranged much faster than project finance.	EPC
Cost of Debt	Project debt is usually more expensive for IPP than corporate debt.	EPC
Loan Tenor	Corporate lending usually has shorter tenures than project lending. However, in case the project is financed by loan taken by GoG, GoG loan may have longer tenor	Case by case
Discipline	The review, contracting and analysis of the project is performed at a higher level for an IPP versus corporate financed project.	IPP
Recourse	Project finance provides protection to the sponsor's balance sheet whereas corporate-financed investments expose a sponsoring firm to losses up to the project's total cost.	IPP
Management Control	In a corporate financing the assets and cash flows would be governed by existing corporate structures. Project finance lenders strictly govern the sources and uses of funds in great detail, leaving very little to management in the way of discretionary powers.	IPP
Transparency	Single asset nature makes a project's performance transparent. In contrast corporate borrowers often have diverse stream of revenues, complicated subsidiary structures and accounting treatments, and cash flow streams that are difficult to analyze.	IPP

Financial and Economic Analysis

Average Tariff (new gas fired power plant only)

Average Tariff (US cents/kWh)	RICE (Wartsila)		Combined Cycle (LM2500 CC)	
Implementation Option	**30 MMSCFD**	**50 MMSCFD**	**30 MMSCFD**	**50 MMSCFD**
IPP	7.1	6.95	7.49	7.35
EPC (commercial loan)	6.64	6.55	6.8	6.7
EPC (DFI loan)	6.17	6.09	6.1	6.0

- IPP tariff is higher than EPC tariff for all cases
- RICE option tariff is lower than Combined Cycle option tariff for IPP and EPC with commercial loan case due to lower capital cost of RICE option
- Combined Cycle tariffs are slightly lower than RICE for EPC DFI loan case as better CC option efficiency compensates for higher CC capital cost at lower cost of capital

Financial and Economic Analysis

Life Cycle Cost Analysis

	Wartsila RICE		LM 2500 CC	
Description	**30 MMSCFD**	**50 MMSCFD**	**30 MMSCFD**	**50 MMSCFD**
IPP				
Life Cycle Costs	669 Million USD	983 Million USD	745Million USD	1,056 Million USD
Upfront Capital Costs including interest during construction	174 Million USD	277 Million USD	284 Million USD	456 Million USD
EPC (Commercial Loan)				
Life Cycle Costs	645 Million USD	950 Million USD	706 Million USD	1,006Million USD
Upfront Capital Costs including interest during construction	171 Million USD	271 Million USD	273 Million USD	440 Million USD
EPC (DFI Loan)				
Life Cycle Costs	630 Million USD	927 Million USD	683 Million USD	970 Million USD
Upfront Capital Costs including interest during construction	162 Million USD	255 Million USD	258 Million USD	413.7 Million USD

Life cycle cost for RICE options is below the life cycle cost of combined cycle options

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Implementation Plan

Project implementation schedule is estimated at 54 months for EPC and 60 months for IPP approach

Project Implementation Plan for New Gas-Fired Power Plant in Guyana
EPC option

GoG Process Activities
Third Party Work

No.	ACTIVITY	Performing Task
1	Site confirmation and initial development approval	GoG
2	Approval of feasibility study	GoG
3	Prepare EIA	GoG
4	Engage Owners Engineer	GoG
5	Project implementation and regulatory approvals	GoG
6	GSA negotiation	GoG - Esso
7	GSA approval and signing	GoG - Esso
8	Complete plant site and transmission line land acquisitions	GoG
9	Prepare project site studies	GoG
10	Gas Treatment Station final design and construction	Esso
11	Prepare Pre-Qualification Documents (RFQ)	GoG
12	Approval of RFQ	GoG
13	Issuance of RFQ	GoG
14	Preparation of the Qualification Package by Bidders	Bidders
15	Pre-Qual Evaluation	GoG
16	Approval of Short-list	GoG
17	Prepare RFP Documents including draft EPC Contract	GoG
18	Approval of RFP Package	GoG
19	Issuance of RFP	GoG
20	Bid preparation, questions, and final submittal by Bidders	Bidders
21	Bid Evaluation	GoG
22	Clarification meetings with top-ranked bidders	GoG - Bidders
23	Approval of Bid Evaluation and selection of Preferred Bidde	GoG
24	Notification of Bid Evaluation	GoG
25	Due Diligence of Preferred Bidder	GoG
26	Approval of Award	GoG
27	Notice of Intent to Award & Invitation to Negotiate	GoG
28	Formation of Negotiation Teams	GoG - EPC
29	EPC contract negotiations with Preferred Bidder	GoG - EPC
30	Final Approval of EPC Contract	GoG
31	Final Contract Signing	GoG - EPC
32	Preparation of plant permit applications	GoG
33	Environmental License and other permit application and ap	GoG
34	Notice to Proceed	GoG
35	Interconnection study approval	GoG
36	Transmission Line construction	EPC
37	Plant construction (Phase 1)	EPC
38	Plant commissioning and testing	EPC
39	Commercial operation (Phase 1)	EPC

Project Implementation Plan for New Gas-Fired Power Plant in Guyana
IPP option

GoG Process Activities
Third Party Work

No.	ACTIVITY	Performing Task
1	Site confirmation and initial development approval	GoG
2	Approval of feasibility study	GoG
3	Preliminary EIA	GoG
4	Engage Transaction Advisor	GoG
5	Project implementation and regulatory approvals	GoG
6	GSA negotiation	GoG - Esso
7	GSA approval and signing	GoG - Esso
8	Complete plant site and transmission line land acquisitions	GoG
9	Prepare project site studies	GoG
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26	Approval of Award	GoG
27	Notice of Intent to Award & Invitation to Negotiate	GoG
28	Formation of Negotiation Teams	GoG - IPP
29	IPP contract negotiations with Preferred Bidder	GoG - IPP
30	Final Approval of IPP Contract	GoG
31	Final Contract Signing	GoG - IPP
32	Preparation of EIA and other requirements for plant permits	IPP
33	Environmental License application and approval	IPP
34	Plant construction permits application	IPP
35	Financial Close	IPP
36	Approval of Financial Close and Notice to Proceed	GoG
37	Interconnection study approval	GoG
38	Transmission Line construction	IPP
39	Plant construction (Phase 1)	IPP
40	Plant commissioning and testing	IPP
41	Commercial operation (Phase 1)	IPP

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Key Findings

- Having firm data on timing, supply quantities, and available reserves of natural gas is critical for project development
- RICE and CC technologies are nearly equal economically, but RICE allows higher fuel flexibility, which reduces gas supply risk
- The GoG needs to decide on the method of project implementation – EPC versus IPP
- Competitive selection of either EPC contractor or IPP developer represents the best international practices
- Gas fired power generation presents significant environmental benefits
- Power evacuation from the new gas fired project at a combination of 69 kV and 230 kV voltage levels is an optimal solution
- Project implementation is estimated to take 54 months for EPC and 60 months for IPP