U.S. TRADE AND DEVELOPMENT AGENCY

EXECUTIVE SUMMARY

Independent Power Plant Feasibility Study in Senegal

February 1, 1999

U.S. Firm: Parsons Energy & Chemicals Group
Main Contact Name: Mr. Lynn Rubow
Current Phone: 610-855-2687
Fax: 610-855-2884

Project Sponsor: SENELEC
Main Contact Name: Mr. Latsoucabe Fall
Current Phone:

TDA Activity Number: 1996-004A
NTIS Number: PB2000106971

Sector: Energy & Power
Region: Africa/Middle East
Country: Senegal

EXECUTIVE SUMMARY

This report presents the results of the Senegal Independent Power Plant Feasibility Study funded by the U.S. Trade & Development Agency (USTDA) under a grant to SENELEC. The primary study objective is the preparation of appropriate technical and financial analyses that will support SENELECs development of an Independent Power Plant as the next addition to their generating fleet. The following sections summarize the completed work, and also present the Parsons Team conclusions and recommendations.

Demand Growth: Basis for New Generation Capacity

SENELEC has a significant need for new electric generation. They experience routine power outages that reduce productive work, impact the social fabric, and stifle economic growth. It is expected that within the next 10 years, SENELEC will retire over 120 MW, or approximately 45% of their presently installed capacity. Many of these units have poor efficiencies; burn high sulfur, heavy oil; and are in poor condition.

The Senegal population is estimated to grow at a rate of 2.6%/year between 1988 and 2010. Meanwhile the country-wide household electrification rate has increased from 20.3% in 1988 to 26% in 1995, and is expected to continue to rise.

As a result, electric demand is expected to grow 5.2%/year between 1997 and 2010. This projection has been made by SENELEC based upon the PVS computer model that simulates growth in the domestic and industrial sectors, while recognizing the impact of new industrial projects. The projected demands are dependent on SENELEC's ability to provide affordable and reliable electric power to attract industry and maintain consumer confidence.

The SENELEC demand forecast appears well substantiated, and serves as a basis for the IPP capacity addition. The peak demand including transmission and distribution losses is presented below.

Senegal has very limited indigenous energy resources, necessitating the import of large quantities of petroleum products.

In 1997, the Senegalese Government announced the discovery of a significant natural gas reserve of approximately 10 billion M3; (200 MWe GTCC for approximately 30 years). PETROSEN's (Soci6t6 des P6troles du S&6gal) preliminary interpretation of test data indicated a proven reserve of only 0.6 billion m3 (20 bcf), but they are hopeful of finding larger reserves. During 1998, the primary existing well was closed, and a new well opened with 5MMft3/day capacity. The reserves are small, however, due to a "compartmented" configuration of the gas cavern. Gas exploration by PETROSEN and Tullow Oil continues; however, the expectations of finding significant gas quantities are lower than even one year ago.

Other indigenous fuels to Senegal include peat, and some uneconomic offshore oil, but none are considered viable fuels at this time. Coal plants were also considered, but were also found to be uneconomical.
Other than natural gas, the only other viable fuels for the IPP are imported liquid fuels, historically a primary fuel for SENELEC. Unfortunately, refined liquid fuels are expensive, and the more affordable heavy fuel oil is environmentally unattractive.

Considering the current state of gas development in Senegal, the IPP feasibility study proceeded on the assumption that natural gas will be available, but an alternate barge-mounted oil-fired plant was developed. Natural gas condensate is considered a cost competitive potential fuel for a barge-mounted plant, or even the land-based plant at Kayar.

Generation Expansion Planning: Selecting the Plant Configuration

To examine SENELEC's need for a new source of power, Parsons has independently developed a generation planning model and performed resource optimization using the ELFIN computer code (Section 4).

The ELFIN program performs maintenance scheduling, commitment, and a detailed economic dispatch of the modeled units and is capable of determining fuel costs, shortage costs, fixed and variable O&M costs, capital costs, marginal energy costs, loss of load probabilities, energy not served, reserve, emissions, and perform resource planning optimization among other things. Optimization algorithms also determine the optimum mix of existing and new resources that will serve the system demand at the lowest possible total cost.

Options considered for potential generation expansion:

- 20 MW Gas Turbine (gas or diesel fuel)
- *60 and 90 MW GTCC (gas or diesel fuel)

- 5 MW Diesel (diesel fuel)
- 20, 60, or 90 MW Diesel (heavy oil fuel)
- 60 or 90 MW oil fired steam (heavy oil fuel)

- 90 MW coal-fired steam

Resource optimizations were performed for natural gas prices of US$4.81 and US$2.70/MMBtu. High gas prices favor the heavy oil burning diesels. Low gas prices favor the gas-fired gas turbine combined cycles.
A sensitivity on natural gas price demonstrated that gas prices above approximately $3.95/MMBtu support the diesel technology; below this price, gas turbines are favored, as shown below. Further, the current gas price of $4.81/MMBtu would not support an investment in a large gas-fired GTCC plant.

Option Selection Consideration is given to both the generation planning results as well as the electric stability analysis (Section 6). The electric stability analysis indicates that a 60 MW unit is stable but that a 90 MW unit is not, and the trends suggest that the unit size be limited to about 75 MW.

The resource optimization process identified specific capacity additions of 60 MW in 2001. Environmental characteristics also favor the gas turbine option burning gas over the diesel option burning high sulfur fuel oil. Therefore, we recommend the addition of a 60-75 MW size GTCC for operation in the year 2001.

Gas Turbine Model Screening Three Frame turbines were selected for review. Major combined cycle equipment was designed, costs estimated, and part load performance developed for Senegal conditions, as shown below:

Manufacturer		**Westinghouse**	ABB	**Siemens**
Model		2511311	GT8C	V64.3
Combined Cycle Cost Data				
Capital Cost	106	57.8	62.7	68.8
Capital Cost	$/kW	887	918	860
100% **Load Point**- GTCC				
Net Power, new	MWe	65.2	68.3	80.0
Net Efficiency, new	%	45.6	47.4	48.2
Net Power, degraded 3%	MWe	63.2	66.2	77.6
Net E id ncy, degraded 2%	%	44.8	46.5	47.2
Annual Fuel Consumption				
Fuel Usage @ 80% CF	10 6 M3/yr	109	110	126

Notes: 1. The combined cycle information has been developed by Parsons on the basis of: 250C (770F), 60% relative humidity, 60 m elevation, dual pressure non-reheat steam turbine, steam temperature of 850 psig, steam temperature set to gas turbine exhaust minus 500F, a wet dry cooling tower, condenser back pressure of 1.5 psia, high pressure, and no air pre-cooling.

Based upon a preliminary electric stability analysis, the larger size of the Siemens V64.3 could create a system stability problem. Comparing the W251 and the GT8C machines, the GT8C, is slightly larger, more efficient, and with a slightly higher specific cost.

Both of these units have significant potential to be effectively utilized in the SENELEC system expansion plan. ABB now offers an upgraded version on the GT8C, the GT8C2, with a slightly higher capacity. The conceptual design effort focused on the ABB GT8C; however, in the bidding stage, the GT8C2, and even the Seimens V64.3, can be reconsidered based on the status of the SENELEC system at that time.

Electric System Studies: Basis for Unit Size and System Location

To develop the Load Flow Analysis, four different generation dispatches were studied, both with the 90 kV bus tie of the Cap des Biches station open and closed. The studies were made with the new 60 MW combined cycle units installed at Tobene and alternately at a new site at Kayar, for a total of 16 different runs. In developing the Kayar generating site, it has been assumed that the 90 kV line between Cap des Biches and Tobene, which is constructed for 225 kV operation, is looped in and out of the Kayar bus.

The Transient Stability Analysis determines the size of the generating unit that the SENELEC interconnected system is able to support. Specifically, this analysis addresses the question: What is the proper size of the installed combined cycle plant that can provide needed capacity to meet system loads until the Manantali hydro is available? Two unit sizes were investigated: 60 MW net and 90 MW net.

The studies were carried out by means of a transient stability analysis of the conditions obtained upon the loss of the most loaded unit (i.e. combined cycle unit). The ability of the system to sustain the loss of a major unit and still maintain proper frequency and voltage, is dependent, in large measure, upon the amount of available unused capacity, or "spinning reserve" in the units that are on-line. Insufficient spinning reserve will result in undesirable load shedding.

The electric system studies demonstrate that the installation of the 90 MW unit will result in load shedding, while the smaller unit will not. For this reason, and the higher reliability obtained with the smaller 60 MW unit, the 60 MW class unit is recommended over the 90 MW class unit. The indicated trends suggest that a generation unit (for the project) of up to 75 MWe is likely to be acceptable.

The analyses also support the generating site development at either Kayar or Tobene, and that the system can operate equally well with the Cap des Biches bus tie open or closed provided that the generating units of Cap des Biches are properly balanced on the two busses.

Site Evaluation: Basis for Physical Plant Location

N'diakhirate, Tobene, and M'boro sur mer (on the sea) sites were originally considered by SENELEC. Two additional sites, BelAir and Kayar, were added during the study. The approximate location of these sites, together with proximity of existing/future natural gas supplies, high voltage lines, and railways is presented below.

The following exhibit presents the results of a qualitative assessment conducted by the Parsons Team, and supported through conversations with the SENELEC staff:

Evaluation Parameter	N'diak-hirate	Tobene	M'boro	BelAir	Kayar
Desired location for economic growth	3	3	4	1	4
Generation diversity	4	4	4	2	4
Environmental Impact	3	4	4	3	4
Existing design data	2	3	2	4	3
Proximity to population areas	4	4	4	1	3
Possibility of future expansion	4	4	4	2	4
Site development risk (substructure)	3	4	4	4	3
Site development cost risk (water)	3	3	4	4	4
Site development cost risk (gas)	4	3	3	2	4
Impact on electric grid stability	2	3	3	4	3
Total Score~	2.91	3.18	3.27	2.45	3.27d

As possible, the following aspects of cost and performance were quantified, considering that the plant would eventually consist of two units totaling more than 140 MWe:

- Site development differences
- Plant design and performance differences,
- Off-site development, and
- Operating cost differences.

The Kayar site is preferred over the second choice, BelAir. By locating the plant near the sea, and close to existing and future gas development, the Kayar site has the best chance of achieving the lowest cost.
A conceptual design and capital requirements of the IPP plant at Kayar were developed and utilized as a basis for financial analysis (Section 8).

Financial Analysis and Structure: Basis for Financing

A previously financed IPP sets a strong precedent and allows Senegal/SENELEC to consider shifting the financial burden of a new plant away from the public sector. The privatization of a majority of SENELEC's shares will bring an international partner who may wish to assume the additional financial burden of the IPP. However, the intent in the current privatization is for SENELEC to evolve as a distribution company, limiting its generation ownership to currently owned plants.

Regarding limited recourse financing, SENELEC has already expended considerable effort to successfully implement an IPP project on a limited recourse basis. Assuming that this expedience can be applied to the new IPP project, the limited recourse option is attractive.

Sources of *Financing*

Each potential source of financing has its own lending requirements. Four general sources, represented by types of institutions, include:

Commercial Banks International commercial banks' participation would be limited to co-financing arrangements with multilateral agencies due to the requirement for political risk and commercial risk guarantees from "Official" sources of financing, i.e. export credit agencies or multilaterals. Consequently, the financing structure for SENELEC begins with "Official" lenders requirements.

Export Credit Agencies Export Credit Agencies (including U.S. Ex-Im Bank, ECGD, Japan Ex-Im Bank, Hermes, SACE, and COFACE) are potential sources of long-term debt financing with more generous terms than those of commercial banks. The Federal Ship Financing Program, US Department of Transportation - Maritime Administration ("MARAD"), is suitable for SENELEC if the new project became a power barge.

Multilateral / Bilateral Institutions The multilateral/bilateral institutions with greatest interest include the International Finance Corporation (IFC) - the private sector arm of the World Bank -, the German Investment and Development Company (DEG), the British Commonwealth Development Corporation, and the US Overseas Private Investment Corporation (OPIC).

Local Banks The participation by local banks will be required primarily for working capital purposes.

Proposed *Financing Plans*

Total Project Costs for the plant are estimated to be $ 74.4 million. Over 80% of the financed amount is eligible for Export Credit Agency funding. We expect that the lenders will require a debt to equity ratio of 70:30. Sources of equity will be the IPP developer with possibly some related project parties. Additional sources may be certain African private equity investment funds (such as New Africa Opportunity Fund).

Two potential financing plans are considered:

Export Credit Agency Lead An ECA can limit the number of lenders for a project to one, thus simplifying the financing process. The project developer must ensure that: (a) Virtually all equipment, engineering, and services are procured from one country; (b) The ECA is "open" for Senegal, and this ECA provides comfort to the liquidity providers under political and commercial risk covers; and (c) The local cost component is limited to approximately 15-20%.

Assuming that much of the procurement will be sourced in the United States, US Ex-Im Bank will be a suitable lender. Ex-Im is capable of doing long tenors for limited recourse transactions and has successfully financed IPPs around the world. We assumed a *12* year repayment term for Senegal, in particular considering SACE's tenor in the GE Capital project. A proven developer and a solid EPC contractor with influence on the ECA will considerably enhance the chances of securing attractive financing terms.

Multilateral and ECA Combination The primary reason for a combination would be greater flexibility of equipment procurement. A multilateral provides untied financing to the sponsors, yet forces international competitive bidding (ICB) for their portion of costs, unless the project itself was won on an ICB basis.

As a first component, the multilateral (or bilateral in OPIC's case) would provide up to 50% of the project costs, with the balance being secured from an ECA. OPIC would be available to the extent the project has a US sponsor with *25%* ownership. The two lender option will increase the financing process costs and incur a longer processing time, with the additional complexity of their respective legal and commercial issues to be addressed.

Analysis and Results

The financial model considers Financing Plan 1 (ECA led). The model targets a minimum debt coverage ratio (DCR) of 1.3 times and a minimum Internal Rate of Return (IRR) to the equity of *23%*.

The tariff was derived using a traditional two-tiered tariff structure (Capacity Charge and Energy Charge), and a slightly declining equity return component over the *20* year period, beginning at US$ *8,500* per kW per month. The *20* year average tariff is US$ 50.77/MWh, with the following tariff profile through the project life:

An IRR of 23.0% is achieved, with a minimum DCR of 1.38. The new IPP has economic viability at reasonable (unescalated) tariffs. A well run competition may result in lower tariffs driven by lower project costs and/or a lower return on equity target.

The Barge-Mounted Plant: The Flexible Option

Since natural gas development in Senegal is uncertain at this time, a barge-mounted plant of equivalent capacity was developed as an alternative to the Kayar land-based plant. Barge-mounted gas turbine plants are seeing increasing application around the world. Senegal is a very appropriate location for a barge-mounted plant application for the following reasons:

- Competitive capital cost,
- Potential short implementation schedule,
- Likelihood of improved financing terms, and

Plant can be relocated to take advantage of a future natural gas supply location.

Our concept consists of developing a "barge-mounted" plant that would initially be located near Bel-Air, within the Dakar Port facility. When natural gas reserves are proven, another study would be initiated with the objective of proving feasibility of moving the plant vs. building a separate greenfields plant and retaining the location of the barge plant.

Initially, the barge plant will be fueled by natural gas condensate, with diesel backup. Gas condensate will be delivered to the existing Port of Dakar storage facilities.

The proposed location for the proposed barge-mounted plant is near the fuel unloading facility in Dakar, in the slip of the abandoned Darse ex-A.C.D. facility, and within 500 m of SENELEC's Bel Air generating facility. A plan view of Port Dakar, identifying the barge location and Bel-Air plant, and the proposed general equipment arrangement on the barge, are shown on the pages following.

Construction of the entire barge assembly would be accomplished in a U.S. shipyard, and would probably be "dry-towed" to Port of Dakar, unloaded, towed by tugs to its final destination, securely moored, and all necessary connections made.