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**SURINAME**

**SUPPORT TO THE INSTITUTIONAL AND OPERATIONAL STRENGTHENING OF THE ENERGY SECTOR**

**CBA FOR PBL - III: FINAL REPORT**

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**SURINAME**

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###

### Background

The electricity sector in Suriname faces serious challenges associated to strong growth in energy demand; inadequate financial sustainability of the electricity service supplied and the resulting financial stress of the power company in charge of the electricity service (*Energiebedrijven Suriname* - EBS); stagnant expansion of electricity coverage in the Hinterlands; and limited technical, institutional and financial capacity to service the grid areas and the Hinterlands.

The Government of Suriname (GSU) have been identifying with IDB’s technical units the priority areas related to the development of the energy sector’s institutional and normative framework. Based on this, a sector strategy is being devised with support from IDB, to design and establish a Sustainable Energy Framework for Suriname (SEFS). The objective of this framework is to increase the efficiency, transparency, sustainability and accountability of the power sector. It has been implemented through Government-budgeted activities and a series of IDB loans and investment grants which include among others, a Policy-Based Loan Program (hereinafter Program) under a programmatic modality (programmatic policy-based loan or PBL) in support of policy reform in the energy sector.

The Program consists of three individual operations (SU-L1022, SU-L1035 and SU-L1036), each with specific institutional and policy goals to be met in 2012, 2013 and 2015, respectively. The first operation and second operations have been approved already in 2012 and 2013, respectively, and the third is under consideration.

Main issues and objectives associated to the Program considered, among others, the following two aspects:

1. A Cost Benefit Analysis (CBA), which was carried out taking into account scenarios “with” and “without” Program execution, associated to the implementation of an efficient expansion plan of the entire Surinamese power system, to supply the increased demand with an acceptable reliability. Without the reforms that are to be undertaken as part of the Program, it would not be possible to carry out the implementation of that efficient expansion plan. This evaluation required the operational simulation of the power system of Suriname with specialized models.
2. Agreement of the following policy objectives: (i) a policy and legal framework to implement a sustainable power sector framework; (ii) technical capacity to implement this framework, including alternative power sources; (iii) readiness to invest in rural electrification; and (iv) a power utility (EBS) that is more financially sound and operationally efficient.

The Bank has retained the consultant Alberto Brugman to perform the following tasks:

1. Review the CBAs prepared for operation SU-L1022 and SU-L1035;

### COST BENEFIT ANALYSIS

###  Introduction

The CBA updated in 2013 identified two indicative generation – transmission expansion scenarios of interest, as follows: i) Base Scenario A: with base demand forecast of 7% annual increase and including the development of the generation capacity in Epar system (with new power plants using HFO in Saramacastraat, Statsolie and Het Vertrouwen) and significant transmission expansions to supply the new demand of the future Newmont gold industry (estimated for 2015 and located in the Southeast of the country) from Epar and Mongeo systems (with new generation based on HFO in this area) and the interconnection of Nickerie and Wageningen systems associated to new generation capacity based on bagasse located in Wageningen, and ii) Base Scenario B: also with base demand and the same new power plants in Epar system but not considering the transmission and generation investment to supply the Newmont gold industry, without the interconnection of Nickerie and Wageningen systems and with the new bagasse power plant substituted by new power plants in Nickerie based on HFO.

It was selected Base Scenario B for the update of the CBA presented in this report considering its higher economic attractiveness in terms of present value of net economic benefits, and the following adjustments were made:

* Adjustment of the Rosebel gold mine power demand according 2013 historical statistics; with this a revision of Epar demand was obtained.
* Representation of total Afobaka power generation, considering its reservoir operation and a probabilistic representation of its hydrological inflows and inclusion of Suralco power demand.
* Decisions in 2013 of the following expansion in EPAR generating system: (i) BEM plant, adjacent to the existing EBS plant at *Saramacca* Street, 63-MW (3 x 21 MW); and (ii) expansion of the *Stichting Pleeggezinnen Centrale Suriname* plant (SPCS - the *Staatsolie* Power Plant) in 34-MW (2 x 17 MW). These two plants were considered as existing plants in Epar System. Also, the itinerary of other new power plants were considered according a new generation expansion program informed by EBS for 2014-2025, including HFO/Natural Gas thermal power engines (& Bagasse in Wageningen) totaling 325 MW and the new Kabalebo hydroelectric power plant (100 MW) in 2022.
* Decision in 2013 of the retrofitting of the two existing 33/12/6 kV substations C and D in the EPAR system, increasing in 22 MVA and 35 MVA, respectively, its operative capacity. Retrofitting and expansion of substation J increasing its operative capacity in 25 MVA and inclusion of the new BOMA substation. The itinerary of the transmission expansion was adjusted according the demand requirement and the connection of new power plants considered in the EBS generation expansion Program. In 2017 it was considered the 69 kV interconnection of the Nickerie and Wageningen systems and in 2022 the interconnection of this two systems with Epar system through the 220 kV transmission system of Kabalebo.
* Substitution for imported natural gas (at US$ 14/MBTU “all in” cost) of liquid fuels used for power generation in Epar system after 2018[[1]](#footnote-1)).

### Assumptions and Methodology

The CBA was prepared taking into account scenarios “with” and “without” the implementation of a Program to expand the Surinamese power system and to meet increased demand. A main assumption for this analysis is that without the reforms that are to be undertaken as part of the Program, it would not be possible to carry out the improvement and expansion plan required to meet demand growth in years after 2014 while ensuring service reliability. Thus, the net economic benefits associated with the expansion plan are considered to be the net economic benefits of the Program.

The CBA evaluates economic benefits derived from: (i) the increase of EBS power sales with respect to 2014 levels, valued at the generation and transmission economic cost; and (ii) EBS’s associated consumer’s surplus in the residential sector, as permitted by the higher capacity facilitated by the Program. The CBA evaluates economic costs associated with supplying demand growth from 2015 onwards, which are: (i) generation and transmission investment costs; (ii) fuel costs incurred to generate electricity; and (iii) Operation and Maintenance (O&M) costs.

A sensitivity analysis was carried out considering variations in: (i) generation and transmission investment costs; (ii) fuel costs incurred to generate power; (iii) cost of hydropower electricity purchases; (iv) O&M costs; and (v) price elasticity.

### II.1 Program description and evaluation approach

The Generation – Transmission Program evaluated includes the following generation and transmission projects identified, preliminarily and in a broad base, as participants in the path of minimum cost expansion of the Generation - Transmission system of Suriname.

Total generation capacity included in the Program is 325 MW representing USD 355.2 million in investment costs during 2014-2025. Also, the power system expansion under the Base Scenario also requires several transmission / sub transmission projects operating at 161 kV and 33 kV, representing USD 259.9 million in investment costs during such period.

The existing G-T system will provide the power service until 2014, when it is estimated that 1,653 GWh will be sold in Suriname[[2]](#footnote-2). After this year, the assumption is that without the Program it would not be possible to supply additional power sales with an acceptable reliability. In this way, the increase of electricity sales after 2014 will be directly associated to the Program.

Next table summarizes the estimation of electricity sales “with” and “without” the Program, constituting the starting point of the estimation of the Program’s benefits.

**SURINAM: ELECTRICITY SALES “WITH” AND “WITHOUT” THE PROGRAM (GWH) 1/**



 1/ Excludes demand & sales to Newmont gold mine (considered with self generation)

Transmission losses were estimated in the simulations and the distribution losses were calculated assuming that total losses will represent 8.2% of total demand[[3]](#footnote-3), similar to recent historical values. Program’s benefits evaluation required the forecast of the electricity demand in Suriname and the application of a methodology to evaluate the consumer’s willingness to pay of the electricity sales associated to the Program. Costs evaluation required the disaggregation in time and in space of the forecasted demand and the application of a Generation – Transmission planning procedure to simulate future power generation dispatch. Also a load flow analysis was required to verify reliability of supply and to estimate electricity losses. For this purposes the SDDP model was applied. Next sections presents the methodologies related to: i) demand forecasts, ii) benefit estimations, iii) G-T system operative simulations and fuel and O&M costs estimations (SDDP model application). Fuel and O&M variable costs were complemented with fixed investment and O&M costs to estimate total costs.

### II.2 Demand forecast

### II.2.1 Historical electricity consumption

Next table shows the national growth of the electricity consumption in kWh for Suriname, starting from the year 2000.

**SURINAME: HISTORICAL ELECTRICITY DEMAND**



Source: EBS (2013)

Average growth of the electricity consumption over the past 11 years is 6.3%. Annual demand growth in EPAR area (6.4%) is higher than in the Districts (4.0%), being Nickerie demand growth the most significant. The demand of Rosebel gold mines is not included in the table neither the Suralco self generation.

Next graph describes electricity usage in Suriname (48% residential, 34% industrial and 18% other sectors).



Source: EBS

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### II.2.2 Energy demand forecasts

Energy demand forecasts were estimated by EBS using future annual average growths similar to historical annual growth of around 7%. It was considered that future EPAR demand covers the specific loads of the refinery expansion and the governmental housing programs. Rosebel demand was estimated considering the historical demand of 2013 and Suralco demand was included according EBS estimations (as self generation with Afobaka hydroelectric power plant). Newmont demand was not included in the analysis and it was considered with self generation.

Next table summarizes total electricity demand foracasted for Suriname and its disagregation: Epar, Nickerie and Districts (including distribution losses), Rosebel gold mine, Suralco (selfgeneration) and the transmission losses estimated with the SDDP model.

**ELECTRICITY DEMAND FORECAST (GWH)**



Source: Consultant revision (without Newmont demand)

**II.2.3 Load duration curve and peak demand**

Peak demand was estimated using the historical monthly load duration curve represented by 5 load blocks (with peak duration representing the 0.36% of time). Next graph illustrates the monthly load duration curve estimated for Epar system, based on the 10 minute demand statistics of May 2012.



The simulations of generation dispatch required the distribution of the annual energy demand by blocks and by months. Monthly distribution factors of energy demand were estimated based on 2011 historical energy demand distribution and then the Block distribution factors for each month of the year were obtained using the typification of the monthly load duration curve. Next table shows the distribution factors applied in the study and the verification of a forecasted peak load of 200 MW for 2012 in September (associated to a total Epar forecasted energy demand of 1,248.4 GWh for this year)..

**POWER DEMAND DISTRIBUTION FACTORS**



Source: Consultant, 2013

### II.2.4 Demand distribution by substations

For generation – transmission planning purposes it was required to forecast demand by systems and for all Epar substations. For this purpose the statistics of peak demand for Epar substations of 2012 and 2013 was used to distribute total forecasted demand for this system. Demand forecasts for each district were also maintained separately for each system. Also, the demand forecast obtained for Nickerie was assigned to the three substations considered in this area after 2018 (Clara, Hennar and Pettenpolder). Next table summarizes the load distribution in Epar substations.

**EPAR: DEMAND DISTRIBUTION BY SUBSTATIONS (MW)**



Source: EBS, 2014

### II.3 Benefit estimations

EBS faces several technical, operational and financial challenges which require Government’s intervention with adequate regulations and management practices to, among others, address financial sustainability issues with the review of the tariff structure adapting the average electricity rate of around US 75/MWh (2012 average, which decreased to US$ 73/MWh in 2013) in order to reflect the real generation, transmission and distribution costs. Current power service in Suriname implies significant subsidies to final consumers that are basically assumed by the State. Such subsidies constitute financial transferences among national agents, not constituting costs or benefits for the national economy.

The Generation / Transmission expansion program will provide an increment of electricity consumption in Suriname, given that without this program EBS would have to restrict power supply up to the current Generation / Transmission capacities. It was considered that this increment would be mainly concentrated in the residential sector. This incremental consumption is the base for benefit estimations and main assumption of the study was the consideration of a referential "cost effective average tariff" of US$ 162/MWh to final consumers during 2014-2017 and US$ 153/MWh after 2017, value estimated with the assumed price of imported natural gas (see ANNEX 1). From the country´s perspective, main economic benefits associated to this program will consist in: a) the increase of EBS power sales valued at its Generation – Transmission economic tariff, plus b) its associated consumer's surplus in the residential sector as permitted by the higher capacity provided by the program[[4]](#footnote-4).

Benefits a) were estimated in US$ 132/MWh for EPAR system and US$ 130/MWh for the gold industries as presented in ANNEX 1 (US$ 116/MWh and US$ 114/MWh, respectively, after 2017). Benefits b) were estimated from the increase of electricity consumption in EPAR system. Next figure illustrates the demand curve in a future time (t=i). From a user´s perspective, net benefits associated to the increase of electricity consumption are estimated as the consumer´s surplus given by area ABC.

**BENEFIT ESTIMATION OF ADDITIONAL RESIDENTIAL CONSUMPTION**

**(2014-2017)**



In the graph Pi correspond to the cost effective tariff (US$ 162/MWh). Consumer's surplus benefits would represent around US$ 135/MWh under the assumption that without the G-T expansion program the 100% of incremental demand in new areas would not be supplied. Also, institutional subsidies to the power service would be around US$ 87/MWh under the assumption of maintaining the existing average tariff P0 of US$ 75/MWh to final consumers.

Consumer's surplus benefits associated to the G-T expansion program were estimated from the definition of Price – Elasticity (*Ε* ): it follows that the derivative of Price p with respect to the quantity q at the point Pi and quantity Qi is given by:

 *dp/dq = Pi/Qi x 1/Ε*

The price that a consumer is willing to pay for a quantity *Qi - Δq* is given by:

 *Pmi = P0 – dp/dq x Δqi*

And the consumer’s surplus is calculated as:

 Consumer’s surplus = (*Pmi* – *P0*) x *Δqi / 2*

In the equation Δqi is the increase of electricity consumption in year i associated to the projects (Δqi = Qmi - Qi), Pmi is calculated with P0 (US$ 75/MWh), E (-0.6) and the percentage Ri (100%) of additional electricity consumed attributable to the G-T program as Pmi = P0 x (1 - Ri/E). It was applied a Price-Elasticity of -0.6, according typical estimations of similar electricity markets in Latin America[[5]](#footnote-5).

### II.4 G-T System operative simulations (SDDP model application)

The determination of the investment, operation, maintenance and fuel costs related to a reliable supply of the increment of electricity consumption in Suriname required the application of a Generation/Transmission planning procedure, mainly focused to: a) identify the most efficient generation and transmission projects required to supply demand, and its execution itinerary in order to estimate the flow of investment costs, and b) estimate the future power dispatch in the power systems from to support the fuel and O&M costs estimations.

The SDDP model was applied to simulate future G-T system operation and expansion, to verify both the expansion requirements as well as the reliability of power supply (on monthly basis and in each of the buses attending local demands). The simulations also permitted to obtain future dispatch of power plants and load flows in the transmission links from which transmission losses, fuel and O&M costs were obtained. These aspects are presented in this section, including the description of the main components of the generation and transmission systems.

### II.4.1 Existing power plants

Next table summarizes the basic characteristics of the existing generation capacity in Suriname, including the recent expansions of EBS (BEM I) with 63 MW and SPCS 5-6 with 34 MW.

**EXISTING POWER PLANTS**



Fuels used and fuel costs are as follows.



Total installed capacity of Suriname adds today 371.3 MW (assigning 125 MW to Afobaka hydroelectric power plant, according the EBS-SURALCO power purchase contract[[6]](#footnote-6)).

### II.4.2 Future and potential power plants

Next table summarizes main characteristics of future power plants considered for the power sector expansion in Surinam during 2014 - 2025 (mostly represented by diesel gensets).

**NEW POWER PLANTS: BASIC CHARACTERISTICS AND COSTS (US$M)**



Kabalebo hydrolectric power plant (100 MW) is assumed to be built through a PPA (US$ 85/MWh)

US$ 100/kW investment is considered for the conversion to Natural Gas of existing Epar power plants

Fuels used and fuel costs are the same as presented for the existing power plants.

### II.4.3 Existing transmission system

The Epar transmission and subtransmission system is conformed at 161 kV and 33 kV. Next graph illustrates the one-line diagram of the system (line impedances are included in ANNEX 2).



For power system (generation – transmission) planning purposes the Epar system and the rest of small systems of Suriname were represented by 96 buses and 50 transmission, subtransmission and distribution links, that are presented in next tables.

**SURINAMESE TRANSMISSION SYSTEM: BUSES**



**SURINAMESE TRANSMISSION SYSTEM: TRANSMISSION & DISTRIBUTION LINKS**



### II.4.4 New transmission and subtransmission systems

Next table summarizes main characteristics of transmission and subtransmission systems considered for the power sector expansion in Surinam during 2014 - 2025 .

**NEW TRANSMISSION SYSTEMS: BASIC CHARACTERISTICS AND COSTS (US$M)**



### II.4.5 Generation / Transmission system expansion analysis

The determination of the investment, operation, maintenance and fuel costs related to a reliable supply of the increment of electricity consumption in Suriname required the application of a Generation/Transmission planning procedure, mainly focused to: a) identify the most efficient generation and transmission projects required to supply demand, and its execution itinerary in order to estimate the flow of investment costs, and b) estimate the future power dispatch in the power systems from to support the fuel and O&M costs estimations.

The SDDP model was applied to simulate future G-T system operation and expansion, to verify both the expansion requirements as well as the reliability of power supply (on monthly basis and in each of the buses attending local demands). The simulations also permitted to obtain future dispatch of power plants and load flows in the transmission links from which transmission losses, fuel and O&M costs were obtained. These aspects are presented in this section, including the description of the main components of the generation and transmission systems.

It was applied a Generation / Transmission planning process to obtain a first approximation of the minimum cost (Investment - Fuel - O&M costs) system expansion that would provide adequate reliability for the Surinamese electricity supply during 2014 – 2025. The SDDP model was applied in a sequential manner to identify the required expansion itinerary of new power plants an lines and a final run permitted to verify the adequacy of the future demand/supply balance on monthly basis and considering optimal power dispatch with transmission losses and constraints imposed by the transmission links (represented by maximum transmission capacities in each link and load flow Kirchhoffs Laws through DC simplified load flows).

This section presents a brief description of the model and its application procedure and the results obtained for the prospective Demand/Offer balance in the Surinamese power sector.

### a) SDDP model

SDDP (Stochastic Dual Dynamic Programming) is a hydrothermal dispatch model with representation of the transmission network and is used for short, medium and long term operation studies. The model calculates the least-cost stochastic operating policy of a hydrothermal system, taking into account the following aspects:

|  |  |
| --- | --- |
| seta | Operational details of hydro plants (water balance, limits on storage and turbined outflow, spillage, filtration etc.); |
| seta | Detailed thermal plant modeling (unit commitment, generation constraints due to "take or pay" fuel contracts, concave and convex efficiency curves, fuel consumption constraints, bi-fuel plants etc.); |
| seta | Representation of spot markets and supply contracts; |
| seta | Hydrological uncertainty: it is possible to use stochastic inflow models that represent the system hydrological characteristics (seasonality, time and space dependence, severe droughts etc.) and the effect of specific climatic phenomena such as the El Niño; |
| seta | Detailed transmission network: Kirchhoff laws, power flow limit in each circuit, losses, security constraints, export and import limits for each electrical area etc; |
| seta | Load variation per load level and per bus, with monthly or weekly stages (medium or long term studies) or hourly stages (short term studies). |

In addition to the least-cost operating policy, the model calculates several economical indexes such as the spot price (per submarket and per bus), wheeling rates and transmission congestion costs, water values for each hydro plant, marginal costs of fuel supply constraints and others.

The SDDP model uses a new solution methodology called stochastic *dual* dynamic programming, developed by PSR (Power System Analysis Inc., from Brazil). This methodology represents the future cost function of traditional Stochastic Dynamic Programming as a piecewise linear function. Because of this feature, it is not necessary to enumerate the combinations of reservoirs levels, which allows the determination of the stochastic optimal solution for systems with a large number of hydro plants.

All the detailed results of the model SDDP are written to \*. csv format files. These files are managed by a graphic interface which produces Excel files with the desired results. The main SDDP results are:

|  |  |
| --- | --- |
| seta | operative statistics: hydro and thermal generation, thermal operation costs, energy interchange, fuel consumption, deficit risks and energy not supplied; |
| seta | short run marginal costs (spot prices) for each submarket and for each bus; |
| seta | marginal capacity benefits: measure of the operational benefit of reinforcing the installed capacity of a thermal plant, the turbine limit of a hydro plant or the storage capacity of a reservoir. These indices are used to determine cost-effective system reinforcements. |

### b) Generation / Transmission system expansion and operative simulations

The Suriname power sector consists of a number of individual power systems. Some of these systems are interconnected while others are operated as an electrical island. The following Figure provides a schematic overview of the different systems currently in operation.



The *EPAR system* for Paramaribo and the surroundings, reaching as far as the Ocean in the North, Stolkertsijver in the District of Commewijne in the East, Carl Francois in the District of Saramacca in the West and The Zanderij (Airport) area in the South. The EPAR system has by far the highest consumption of electric power in Suriname (total demand in this system was 1,218.9 GWh in 2012, see ANNEX 4 containing the G-T diagram of this system);

The *ENIC system* for New Nickerie in West Suriname, and the surroundings reaching as far as Groot Henar in the West (total demand in this system was 68 GWh in 2011);

The *Rural District* Power Systems, each operating as an isolated power system with one or more Diesel Generator Sets in a local power house and located at: Albina, Moengo, Boskamp, Coronie, Wageningen, Apoera (total demand in these areas was 29 GWh in 2011);

The *Rosebel Gold Mines* where the Gold Mine operations of IAMGOLD in the Brokopondo district are supplied with electric power via a dedicated 161 kV overhead power line coming from Afobaka Hydro power Plant, built and owned by IAMGOLD (total Rosebel demand was 193 GWh in 2011);

The *Brokopondo* Distribution system feeding some villages in the Brokopondo district from the 13.8 kV system at the Afobaka Hydro Power Plant and several small power systems exist in interiorof Suriname, which systems are owned and operated by the Department for Rural Energy of the Ministry of Natural Resources (DEV).

One indicative generation – transmission expansion scenario was identified of interest for the simulations, considering:

1. Base demand forecast.
2. Development of the generation capacity during 2015-2022 in Epar system with new power plants based in HFO/NG, a new hydro in 2022 (Kabalebo) and then more HFO/NG power plants.
3. The new demand of the future Newmont gold industry (located in the Southeast of the country) with self generation. Not included in Epar system.
4. New power plants in Nickerie and Wageningen based on HFO and Bagasse and a 69 kV interconnection for these two systems in 2018.
5. Availability of imported natural gas in Epar system starting in 2018 and conversion of the existing power plants to use this fuel (with US$ 100/kW as investment cost).
6. In 2022 with the commissioning of Kabalebo hydro power plant a 220 kV transmission system connecting this plant to Nickerie, Wageningen and Epar.

This scenario was constructed first by selecting the itinerary of the new power plants to supply demand in Epar and Nickerie systems according EBS estimations and then obtaining the timing for the required transmission and subtransmission expansions (at 161 kV and 33 kV) in the Epar system to guarantee the electricity supply in all substations, considering the new transmission projects identified for the systems. In this scenario Moengo, Apoera, Coronie and Albina small systems remain isolated and self sufficient in power generation.

The simulation of this scenario was done with the SDDP model and using a data base constructed to represent future demand during 2014-2025 (by months and for five demand blocks) and all existing and future power plants, transmission lines and subtransmission substations up to the level of 12 kV and 6 kV. The Epar (including Rosebel) and Nickerie systems were represented separately and the Districts system considered the Wageningen, Coronie, Apoera, Mongeo and Albina loads. The simulations represented the minimum cost of power dispatch (including transmission losses) for the system considering 27 power plants, 96 buses and 90 transmission links.

The prospective and the electricity Demand/Suply forecasts obtained from the simulation of this scenario is presented next. Those results constitute the support for the Cost-Benefit evaluations presented in next chapters. Next graphs summarize the peak demand forecasts and generation expansion programs obtained for each system under this scenario.

 

 

  

 

Next graph present the marginal cost of demand forecast obtained for Epar system, ranging around 140 – 160 USD/MWh during 2014 – 2017 and decreasing to the range of US$ 127-120/MWh in the long term.



The aggregation of all loads, losses and dispatched power in Suriname is presented next in the electricity balance forecast.



### III. Economic Benefits

Next tables summarize the forecasted Program’s demand and benefit estimation (consumer’s surplus and generation- transmission benefits) associated to the scenario evaluated.

**PROGRAM DEMAND (GWH) AND BENEFITS (US$M)**



### IV. Economic costs

Next tables summarize the total cost itinerary associated to the scenario evaluated.

**TOTAL COST ITINERARY (USDM)**



### V. Economic returns

Next table contains the itinerary of Benefits and Costs associated to the G-T expansion Program. The economic rate of return (ERR) is 14.7% and the present value of its net benefits (at 12% discount rate) is USD 94 million.

**COST BENEFIT ANALYSIS**

**(US $ Million)**



Next table contains the sensitivity of the results obtained to changes in main parameters considered in the economic evaluation.

**SENSITIVITY OF NPV & ERR**



Results obtained in the sensitivity analysis indicate that changes of around 20% in main parameters intervening in the economic evaluation, the ERR will result higher than 12%, excepting in a 20% increase in fuel costs, which would imply an ERR of around 10.9%.

### VI. Some conclusions

The following conclusions could be obtained for this report.

* The power generation – transmission planning activity in Surinam requires support to identify the best solutions of an economically efficient power system expansion. A power planning procedure should be institutionalized based on the application of appropriated technologies and models. The experience obtained in this study indicates that models as the SDDP could be very helpful for this task. However, additional demand forecast and optimization models should be applied to verify and revise the investment itinerary of the least cost expansion.
* Results obtained in this report indicate lower economic returns than obtained in former reports. This is due mainly to the following two aspects: i) a substantial increase in fuel costs due to higher heat rates informed by EBS for the existing and future power plants, ii) higher level of reserve margins in the generation expansión program and more redundancy considered in the transmission expansions as estimated by EBS.
* The generation options to guarantee future electricity supply are mainly related to high cost liquid fuels and efforts should be done to identify additional options. This report includes the option of substitute for imported natural gas the liquid fuels used in Epar system for power generation in 2018, reducing future electricity costs. This aspect could also be revised in the future considering the new lower HFO prices expected in the international market.
* Transmission requirements are also significant in Epar system and its study and evaluation also imply significant efforts to identify the appropriate transmission/subtransmission expansions in this system. The optimal expansion of these systems should be carefully studied in the future.
* Nickerie and Wageningen systems could be interconnected. Other isolated systems are still very small and its interconnection to the main grid may not be economical yet.
* From a national perspective, the Surinamese generation – transmission system expansion is economically attractive to supply future demand increase in the country and, conceived with minimum cost criteria, will provide significant economic returns. However, given the current institutional, financial, electricity prices and regulatory status, there are significant risks that the real future system expansion would not be the optimal, implying a decrease of its net economic returns for the country.
1. Natural Gas in the Caribbean—Feasibility Studies, Final Report (Volume I), Draft Report to the Inter-American Development Bank, Castalia, 30 June 2014. It should be mentioned that this CIF "all in" Natural Gas price may be also viewed as a HFO future price in a new international liquid fuel price scenario (and if such would be the case it would represent and scenario without HFO for natural gas substitution). [↑](#footnote-ref-1)
2. 1,389 GWh to EPAR and Districts and 128.4 GWh to Rosebel Gold Mines and 125.3 GWh to Suralco (Afobaka self generation). [↑](#footnote-ref-2)
3. In 2012 EBS electricity demand (without Rosebel gold mine) was 1,305.2 GWh and electricity sales (without sales to Rosebel) were 1,197.1 GWh (91.7%, implying transmission and distribution electricity losses of 8.3% of total demand). [↑](#footnote-ref-3)
4. This assumption will imply that future electricity consumption per capita in Suriname will remain similar to its current value of around 2.230 kWh per capita/year. However, in case of a significant tariff readjustment to levels similar to the “cost effective tariff” (implying increases of around 130%), this consumption may be reduced significantly (for example other similar economies with higher electricity tariffs have lower per capita electricity consumption, as Honduras, 669 kWh per capita/year, Guatemala 559 kWh per capita/year, Bolivia 603 kWh per capita/year, etc.) [↑](#footnote-ref-4)
5. Price elasticity of electricity demand is a measure used in economics to show the responsiveness, or [elasticity](http://en.wikipedia.org/wiki/Elasticity_%28economics%29), of the quantity demanded of electricity to a change in its price. More precisely, it gives the percentage change in quantity demanded in response to a one percent change in price (holding constant all the other determinants of demand, such as income). Another indicator is Income elasticity of demand which relates percentage change of demand related to percent income variation. Both indicators permit the modeling of the behavior of the consumers to price and income variations permitting the estimation of the economic value of the consumed electricity. This situation has been empirically and theoretical supported in several Latin American countries. Suriname does not count with specific studies at this respect, for this reason in this study it was applied the experience in other Latin American countries. In Chile, recent studies indicate that the price elasticity of residential demand is -0.27 for one year and -0.39 for longer terms. Westley estimated it in -0.5 for Paraguay (1984) and in -0.45 for Costa Rica (1989) and Berndt & Samaniego in -0.47 for México (1984). In summary, available studies indicate that long term price elasticity of residential demand is in the order of -0.4 to -0.5. Based on such experiences, for the study it was adopted -0.6 as a conservative average price elasticity of electricity demand for residential sector in Suriname. [↑](#footnote-ref-5)
6. Afobaka has 189 MW of installed capacity and Suralco uses around 17 MW as self generation for its aluminum industry. Its generation was represented in the SDDP model with its seasonality and probabilistic monthly variation based on synthetic stream flow generation (see ANNEX 3). [↑](#footnote-ref-6)