

NORAD

Review of the Amaila Falls Hydropower Project in Guyana

Final Report



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Summary

Since 2009 Norwegian International Climate and Forest Initiative (NICFI) has supported Guyana's efforts for protecting its rainforest from exploitation and degradation and for changing its currently oil fuelled electricity sector to emission-free power generation. As reward for Guyana's endeavours towards these goals, Norway in 2014 deposited USD 80 million in the Inter-American Development Bank (IDB) earmarked for Guyana's equity share in Amaila Falls Hydropower Inc (AFHI), a Special Purpose Company for realising the 165 MW Amaila Falls Hydropower Project (AFHP) as a public/private partnership BOOT project supported by IDB.

Sithe Global, the private partner and main sponsor in AFHI, withdrew from this position in August 2013 after the Guyanese National Assembly did not vote unanimously in favour of a proposition presented by Sithe Global for certain project features, including raising the ceiling for maximum annual payment by Guyana Power and Light (GPL) as power off-taker. Thereafter, efforts continued, supported by IDB, to establish a new main sponsor in AFHI. This came to a standstill after a new coalition government created by the earlier opposition parties took power after the parliamentary elections in May 2015. The new government has confirmed its devotion to the Low Carbon Development Strategy (LCDS), which was introduced in 2009 by the former government and confirmed by its updated LCDS declaration in 2013.

With the aim of finding a way forward for the transition of Guyana's power generation system, Government of Guyana represented by the Minister of Finance and the Minister of Natural Resources and the Government of Norway represented by the Minister of Climate and Environment, decided in December 2015 to perform "an objective and facts-based" assessment of AFHP.

On June 20th 2016 NORAD (Norwegian Agency for Development Co-operation), in support of NICFI signed an agreement with Norconsult AS for carrying out an initial analysis. Main conclusions and recommendations are presented below:

The only realistic path for Guyana towards an emission free electricity sector is by developing its hydropower potential. The fastest way forward is to maintain AFHP as the first major step for substituting its current oil fired generation. AFHP was prioritised as the first hydropower plant because it was the only project with a full feasibility study completed, it has a higher plant load factor than the alternatives, a smaller reservoir and a levelised unit cost in the same range as the most attractive alternatives.

Amaila Falls alone cannot provide a 100% emission free power generation in Guyana. Other generating sources will have to be added in parallel like sun, wind and thermal production based on emission neutral fuel (bagasse) for back-up in the dry periods when the water flow to AFHP may be insufficient for full capacity operation. As the power demand is growing, and for reaching the goal of 100% emission free generation by 2025, as assumed by the LCDS, a second hydropower plant of capacity comparable with AFHP will have to be commissioned by 2025. In parallel with preparations for AFHP, therefore, pre-feasibility studies will have to be carried out for promising candidates for the second hydropower project and a full feasibility study be performed for the selected candidate.

The environmental and social impacts of AFHP are well established in the performed studies. No resettlement is required and there is limited human activity in the area directly affected by the project. About 23 km² of rainforest is inundated by the power plant's reservoir. The live storage volume is small compared to the annual water flow and the plant will be operated mainly as a run-of-river plant with little impact on the downstream river hydrology, except for the about 4 km stretch of the river between the intake dam and the tailrace outlet from the powerhouse. The most serious threat to the environment that may result from the project is the access road, which is almost completed and has already, while the further progress of the project itself is uncertain, created easier access for mining and exploitation of the forest along its alignment. A strict control regime is required for obstructing such activities. It is important to take up again consultations with all affected parties as soon as resuming the project preparations.

Other hydropower plants that could have replaced AFHP as the first hydropower project to be implemented, would require 1-2 years of investigations and studies, including environmental and social impact assessments meeting today's standards, to reach an updated feasibility study stage comparable to AFHP.

The first needed step for revitalising AFHP is decision by the Government to maintain AFHP as the priority project in the transition to a green generation regime, as recommended in the "Initial Study on System Expansion of the Generation & Transmission System" of 2014 and reiterated in "Guyana's Power Generation System Study" of June 2016, and thereafter to resume the planning of Amaila Falls with political consensus and understanding with all stakeholders.

It is our opinion that the BOOT type public private partnership model should be maintained for the project implementation. An internationally well merited investor and operator in the hydropower industry should be invited to take the majority position and the driving seat (main sponsor) in the project company. The main sponsor and the EPC Contractor should not be associated in any way.

By restructuring the financial model, the risk for Guyana's economy can be reduced. The annual payments from GPL may possibly be reduced by 20%, which are significantly lower than the current fuel costs paid by GPL for its oil fuelled generation. The risk to Guyana's economic stability would be at the same level with other projects generating the same amount of energy, as the investment would be of a similar magnitude.

It is our opinion that the EPC tenders from 2008 are outdated and need to be replaced by a new EPC tender process. Before that, certain technical features of the project should be reviewed and the EPC tender documents be updated. In order to save time this work should be done in parallel with identifying and assigning a new main sponsor.

To get on with these activities GOG will need continued support by IDB, or a similar institution, and Guyana Light and Power will need technical and management support by a highly qualified engineering company with extensive experience from the international hydropower industry. If later agreed between the parties, the same engineering company may continue in a role as independent engineer in the relation between GOG/GLP and the new main sponsor.

We may suggest that the cost for buying out Sithe Global from the project company and expenses for services by an engineering company engaged for support until a new main sponsor is established, are covered from a portion of the USD 80 million deposit in IDB for later being turned into equity contribution from GOG to the project company.

Our estimate is that 3 years will be required from a decision is taken to resume project preparation for AFHP until Financial Close and Notice to Commence to the EPC Contractor.

From this point in time, we estimate another 3.5 years for construction until start commercial operation of Amaila Falls Hydropower Project.

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LIST OF ABBREVIATIONS

AFHI	Amaila Falls Hydro Inc.
AFHP	Amaila Falls Hydropower Project
BOOT	Build, Own, Operate & Transfer
CRFG	China Rail First Group
DAI	Direct Area of Influence
DBIS	Demerara/ Berbice Interconnected System
DO	Dissolved Oxygen
DRIFT	Downstream Response to Imposed Flow Transformations
EFR	Environmental Flow Requirement
EIA	Environmental Impact Assessment
ESIA	Environmental & Social Impact Assessment
EPC	Engineering / Procurement/ Construction
GHG	Greenhouse Gases
GL	Generation Licence
GOG	Government of Guyana
GPL	Guyana Power & Light
GSEC	Ground Structures Engineering Consultants Inc.
HFO	Heavy Fuel Oil
IA	Implementation Agreement
IAI	Indirect Area of Influence
IDB	Inter-American Development Bank
IE	Independent Engineer
INDC	Intended Nationally Determined Contribution
IPP	Independent Power Producer
LCSD	Low Carbon Strategy Document
MEF	Minimum Environmental Flow
MW	Megawatt
MWH	Montgomery Watson Harza

NICFI	Norway's International Climate and Forest Initiative
NORAD	Norwegian Agency for Development Cooperation
PPA	Power Purchase Agreement
PV	Photovoltaics
SG	Sithe Global
SPC	Special Purpose Company

1 INTRODUCTION

Exploitation of the hydropower potential at Amaila Falls in Guyana has been on the planning stage for decades. In August 2013 the preparations for implementation of Amaila Falls Hydropower Project came to a standstill as the Parliament of Guyana did not vote unanimously in favour of certain features of the project presented by its main sponsor, Sithe Global, a US based investor in the international energy market. Thereafter, Sithe Global withdraw from its position as main sponsor.

With the aim of possibly bringing the situation out of the current deadlock, the Government of Guyana (GOG) represented by the Minister of Finance and the Minister of Natural Resources and the Government of Norway represented by the Minister of Climate and Environment decided at a meeting in Paris in December 2015 to perform "an objective and facts-based" assessment of Amaila Falls Hydropower Project.

NORAD, in support of the Ministry of Climate and Environment's International Climate and Forest Initiative (NICFI), signed an agreement with Norconsult AS of Norway for carrying out an initial analysis in this respect on June 20th 2016.

Norconsult started its work on July 1st after Amaila Falls Hydropower Inc., the Special Purpose Company established for realising the project, admitted Norconsult AS access to a selected compilation of the project files for the project covering proceedings up to August 2013.

In addition Norconsult has received various information, reports and other documents related to Amaila Falls from Sithe Global and the Inter-American Development Bank and on the Guyanese power system from Guyana Light and Power. We have had telephone interviews with several key persons who have been involved with the Amaila Falls project in later years. We will thank all we have contacted for valuable contribution to our understanding of the Amaila Falls project and the energy sector in Guyana.

2 BACKGROUND

2.1 Energy Sector in Guyana

The electricity supply in Guyana is currently generated by thermal plants, mostly fuelled with imported heavy fuel oil (HFO) and diesel oil. Guyana Power and Light (GPL), a (100%) state-owned power company, is a vertically integrated utility in charge of most of the country's electricity generation and distribution. The majority of its customers are served by the interconnected Demerara/ Berbice (DBIS) grid around the capital Georgetown and along the south-eastern part of the coast line. The currently available generation capacity connected to DBIS is 164.9 MW, the majority fuelled with HFO. Included in this figure is Guysuco, a state owned sugar producer operating as Independent Power Producer (IPP), with an available capacity of 38 MW, of this 30 MW fired by sugar cane bagasse, and 8 MW with HFO¹.

Most of the very sparsely populated hinterland is not supplied from the GPL grids.

Peak demand in the grid served by GPL has increased by 3.5% in average per year since 2008. In 2015 the peak demand was about 110 MW and GPL's total electricity production was 749 GWh². Guyana's population: 799,613³. Consumption of electricity per capita: ~800 kWh/ year (2015, technical losses in the distribution system not included).

Considering plans for connection of currently isolated grids to the DBIS system and the projected growth in the Guyanese economy, the forecast power demand (base case) for 2025 is 1503.5 GWh⁴.

Inter-American Development Bank (IDB) has been providing institutional and technical support to GPL over several years, most recently through the "Power Utility Upgrade Program" of October 10, 2014, with the objectives of improving GPL's: (i) management and administration; (ii) system planning and design; (iii) information technology; (iv) infrastructure requirements; (v) commercial operations; and (vi) infrastructure to allow for loss reduction, consistent with GPL's Development and Expansion Programme.

Guyana has made a commitment to transfer its currently oil fired power generation to renewable energy sources. A Low Carbon Strategy Document (LCSD), outlining the way forward towards such goal, was sanctioned by the former Government in March 2013. The commitment has been confirmed by the current Government at the United Nation's conference on climate change in Paris in December 2015 and in the Indented Nationally Determined Contributions (INDC) that GOG submitted to the UN's Framework Convention on Climate Change in 2015.

Compared to its domestic power demand, Guyana has large untapped sources of hydropower⁵. Switching the bulk of its power generation to hydropower would be an effective main strategy, and probably the only realistic one, for transition of its power sector towards emission free generation.

Guyana is at the starting point of developing its hydropower potential. The investment required for a hydropower project with a capacity that can be a driver in Guyana's transition to renewable generation, is very large compared to the size of Guyana's fiscal economy and conditions do not seem ripe for undertaking a hydropower project of this scale as a pure public enterprise. The intention of GOG, as supported by IDB, has been to involve a foreign developer for implementing the country's first major hydropower project.

¹ All figures taken from "Guyana's Power Generation System Expansion Study" June 2016

² Information received directly from GPL. The figure includes technical and non-technical losses in the distribution system.

³ Source: World Bank (2013)

⁴ Source: "Guyana's Power Generation System Expansion Study" June 2016

⁵ Guyana's exploitable hydro potential has been estimated at 8,400 MW ("Guyana's Power Generation System Expansion Study" June 2016)

2.2 History of the Amaila Falls Hydropower Project

In 1974-76 GOG carried out a pre-feasibility study of the hydropower potential at Amaila Falls assuming an installed capacity of 200 MW. In 1997, a brief review of this study was done by others. It concluded by suggesting a 165 MW development.

In 1998 GOG signed an MOU with Synergy/Harza for developing Amaila Falls in the private sector. In December 2001, Montgomery Watson Harza (MWH), on behalf of Synergy/Harza, completed a feasibility study of the project with installed capacity downscaled to 100 MW.

In 2006 Sithe Global (SG) entered as potential investor to the Project. GOG and SG thereafter established a Special Purpose Company (SPC), Amaila Falls Hydro Inc (AFHI), for developing Amaila Falls Hydropower Project (AFHP). Partners in AFHI are Sithe Global (60%) and GOG represented by Guyana Power and Light (GPL) (40%). GPL is supposed to be the sole direct off-taker of the power from the Project.

AFHP comprises a power plant with 165 MW installed capacity and a 270-280 km long 230 kV double circuit transmission line via a sub-station at Linden to the capital, Georgetown. Access road to the project site is near completion constructed by the Government. Construction cost of the road may cover a part of Guyana's share capital in AFHI.

The intention has been to develop AFHP in a BOOT (Build, Own, Operate & Transfer) model with transfer of the facilities for free to GOG after 20 years.

On Oct. 8th 2009 the original holder (an association of Synergy Holdings (Guyana) and Harza International) of an Interim Development Licence, transferred all rights and interests, obligations and liabilities under its licence to AFHI.

In 2010 IDB assumed a role as adviser to GOG and AFHI for developing the project and for establishing a structure for the financing of AFHP involving support from IDB, potential development agencies and other sources.

A draft Power Purchase Agreement (PPA) (on "take or pay" basis) between AFHI and GPL was negotiated in 2011.

After competitive bidding between five pre-qualified candidates, AFHI in 2008 selected China Rail First Group⁶ (CRFG) (in association with North West Hydro, a design bureau in Xian, China) as EPC⁷ Contractor. The EPC Contract was executed on December 12th 2012. Implementation Agreement (IA) with Government of Guyana (GOG) and Power Purchase Agreement (PPA) with (GPL) were negotiated. The validity of the original interim Generation Licence (GL) was extended to Dec.31th 2013.

As condition for continuing as main sponsor to the project, Sithe Global in August 2013 required unanimous sanction by the Guyanese National Assembly of Sithe Global's updated proposition on certain project features. The larger opposition party, however, voted against⁸. Consequently, Sithe Global withdrew from its position as developer and main sponsor.

Thereafter CRFG aspired to take over Sithe Global's role as main sponsor in the SPC, while at the same time carrying on in its role as EPC Contractor. In January 2015, IDB issued a Mandate Letter to CRFG specifying strict conditions set by the Bank for its continuous support to the Project under the changed circumstances. CRFG signed the Mandate Letter and negotiations went on for some time, including preparations for buying out Sithe Global and replace SG with China Rail as major partner in AFHI. In May 2015 a draft "Share and Asset Purchase Agreement" had been reached with Sithe Global for transferring its shares, assets and rights in AFHI to China Rail. This agreement has not been executed.

The former GOG lost power at the Parliamentary Election in May 2015. The former opposition parties created a new coalition Government and the key persons, who had been involved in promoting the Amaila Falls Project under the former Government, left office. The negotiations with China Rail were

⁶ CRFG had been prequalified as candidate bidder in association with North West Hydro, a design institute in Xian, China, representing the electro-mechanical expertise and experience in the association, while the lead partner CRFG, while lacking merits as EPC Contractor from major hydropower projects, was pre-qualified for its extensive background in tunnelling.

⁷ EPC = Engineering/ Procurement/ Construction. The EPC Contractor takes on responsibilities for: (i) the design based on an Owner's Requirement Document; (ii) procurement of all electromechanical equipment and civil works construction; and (iii) coordination of all works, all at a fixed price and within a fixed time for completion

⁸ The larger opposition party voted against the proposed agreement opining that the tariff to be paid by GPL, the financial risk and other conditions on GPL and GOG, were unacceptable.

interrupted shortly after the new GOG took office and have not been taken up later. The Mandate Letter of January 2015 expired after 12 months.⁹

AFHI still exists as a company although in a "lame duck" state after the withdrawal of Sithe Global as project sponsor and developer. The Interim Generation Licence has been withdrawn, while the Implementation Agreement and the Power Purchase Agreement never came into effect.

2.3 Involvement by Norway

Norway's Ministry of Climate and Environment and its International Climate and Forest Initiative (NICFI) have supported Guyana's rainforest conservation efforts since 2009, including Guyana's commitment to the transfer of its oil fired energy generation to renewable sources, as outlined in Guyana's Low-Carbon Development Strategy (LCDS) document issued first in 2009 and confirmed in a revised version in March 2013.

As a reward for Guyana's successful efforts to preserve its rainforest since 2009 and follow-up of its low carbon development strategy, Norway has since 2010 paid about USD 150 million to Guyana, based on Guyana's results in keeping a low deforestation rate and improving forest governance. Of this amount Norway in November 2014 signed an agreement to deposit USD 80 million in IDB, available for a larger part of Guyana's equity share in a restructured AFHI (or in another SPC that may substitute AFHI) for realising the Amaila Falls Hydropower Project, conditional on acceptance by IDB for continuing its role in establishing a loan operation for the project financing.

Norway is awaiting Guyana's decision on whether to move forward with the AFHP before a decision is taken by the end of 2016 on how to allocate the USD 80 million in line with Guyana's LCDS.

⁹ During the years after CRFG was selected as EPC Contractor in 2008, serious corruption charges have been raised against CRFG's parent company related to domestic affairs in China. This has caused the The Norwegian Government Pension Fund Global to dispose of its shares in CRFG. It is not likely that Norway could accept to maintain its support to the project if CRFG reappears in a key development role for AFHP like sponsor or EPC Contractor.

3 PRESENT SITUATION

At the moment it does not seem to be any progress towards implementation of Amaila Falls Hydropower Project.

AFHI is still incorporated with assets mainly comprising project documentation, while most of, or all, previous licences and agreements have expired or did never take effect. With Sithe Global still as the main partner and majority owner, AFHI lacks the driving force for advancing Amaila Falls Hydropower Project.

Once SG has withdrawn as sponsor for AFHP, it seems quite unlikely that SG may return to its former position. In order to bring AFHP forward, AFHI has to be revitalised with a new main sponsor instead of SG, or alternatively, a new Special Purpose Company may be created, replacing AFHI. The choice is a political decision to be made by GOG.

In any case AFHI's technical plans and project documentation and remaining rights and licences, if any, will be of great interest and value for the new sponsor taking over as project developer. The current rights to this material, if there is any doubt as to whom the different parts belong, need to be clarified as soon as possible and negotiations resumed aiming to replace SG with another sponsor/ majority partner in AFHI. Such negotiations have to be driven by GOG, preferably supported as before by IDB, alternatively by another supporter. As an interim solution, until a new sponsor is in place, GOG may take the position as 100% owner of the AFHI. If agreed by Norway to be within the statute for use of the money, the buy-out of SG could be paid from the USD 80 million presently deposited in IDB, which anyway is earmarked as part of Guyana's share in the SPC.

In 2009 the former Government issued a Low Carbon Development Strategy (LCDS), reconfirmed in 2013, stating its commitment to switch most of Guyana's current oil fuelled energy generation to renewable sources with implementation of Amaila Falls as the front runner component of such transition. The LCDS commitment is confirmed by the current Government in its document "Intended Nationally Determined Contributions" presented to the United National Framework Convention on Climate Change in 2015. From page six of this document is quoted: "---, with the provision of adequate resources¹⁰, Guyana can increase its share of renewable energy by 100% by the year 2025".

Since Guyana issued its updated version of the LCDS document in 2013, two studies have been made on the generation system expansion in Guyana, available in the two reports:

- (1) "Initial Study on System Expansion of the Generation & Transmission System" of July 23th 2014, and
- (2) "Guyana's Power Generation System Expansion Study" of June 2016.

The second study is made at the new Government's initiative as an update of the first one, by including perspectives of a possible interconnected transmission system with Brazil and Suriname and natural gas as a potential fuel for thermal plants in the longer perspective.

The Amaila Falls Project is a main component in the recommended generation expansion plan in both study reports. The goal of about 100% renewable energy use in 2025 (and beyond), however, is not reflected anywhere in the studies, which have least cost development as their governing parameter, without considering the global climate cost perspective.

Study (1) suggests coal fired plants for covering growth in power consumption after 2030, while Study (2) suggests natural gas fuelled plants for such time perspective.

This is further commented under Section 4 in this Report.

GOG is currently working on its Energy Policy and aims to have ready a "Green Paper" on the subject by December 2017¹¹.

¹⁰ Understood: Including the support from NICFI, as well as from others?

¹¹ Source: IDB

Due to GPL's lack of institutional and financial strength, and GPL having no earlier experience in hydropower development, we think it out of the question that Guyana may be able to implement its first major project as a 100% public sector undertaking.

We are fully aware of the circumstances, which lead to the negotiations with China Rail after SG withdrew from its position. The double role as main sponsor/majority partner in an SPC and EPC Contractor in an agreement with the SPC, as tried with China Rail, however, is not a concept that we would recommend in a possible effort to revive AFHP. It would implicate serious conflict of interests between the main sponsor's two roles. His first priority would certainly be as EPC Contractor, which would put SPC as minority partner in the SPC and as power off-taker in an unfavourable position. Introducing an Independent Engineer in such case for overseeing the proceedings in the SPC, might have improved the situation somewhat, but not solved the basic problem.

Re-establishing the arrangement with China Rail on the same basis as before, might seem to be a faster track than starting all over from square one with a new EPC Contractor. As said above, we would advise against it, by the inherent conflict of interest it implies, as well as by other reasons covered elsewhere in this Report.

We do not see that a new EPC Contract can be negotiated and assigned based on the EPC proposals received 8 years ago considering that SG, who was instrumental in managing the EPC tender process at that time, now is out. In addition, general requirements for transparency in a tendering process could hardly be satisfied by taking up negotiations based in these old tenders. AFHP is apparently back at the pre-EPC tender stage.

By proceeding with the necessary steps of project preparation in a most efficient order and manner, it is our judgement that it may take 3 years from decision is taken to move forward with project preparations until the project stage of August 2013 could be regained.

Within this period of time SG will have to be bought out from its position in AFHI, including transferring all its current rights, if any, and ownership of project assets to GOG. A new main sponsor is required in AFHI (or in a new SPC substituting AFHI). A new Development Licence and a new Implementation Agreement will have to be issued to AFHI (or the new SPC) and a new PPA will have to be negotiated. Some supplementary site investigations should be carried out and the EPC tender documents should be updated. A limited number of pre-qualified candidates for tendering have to be selected, an EPC tendering process be launched, tender evaluation done, contract negotiations carried out and a new EPC contract assigned. In parallel with these preparations the financing of the project will have to be prepared, decision made whether export credits including debt financing should be part of the EPC tender process, all with aim to make AFHP ready for financial close once the EPC contract has been assigned.

The draft GL, IA and PPA documents have to be reviewed and revised in the light of conditions that need to be sanctioned by the present GOG and supported by the main opposition party in order to reduce the political risk for the new sponsor.

As explained under Section 7 in this Report, a few technical aspects of the project need to be reviewed as well and appropriate changes made in the "Owner's Technical Requirements" and the EPC tender documents revised accordingly before new candidates are invited to prepare their EPC proposals.

Provided that financing has been secured in parallel with the technical project preparation and financial closing is achieved at the same time, it is our preliminary assessment that commissioning of AFHP may be expected 6 ½ years after a decision has been made to move forward.

4 EMISSION OF GREENHOUSE GASES

4.1 Guyana's Commitment to Emission-free Electricity Generation

Under item "1. Objective" in the TOR for Norconsult's engagement is stated:

"The exercise is part of a wider scope to identify the best options for Guyana's transition from reliance on liquid hydrocarbons for electricity generation to renewable sources to accomplish Guyana's commitment to increasing its renewable energy use to some 100%¹² by 2025."

Implementing Amaila Falls Hydropower Project (or another hydropower project of a similar generation capacity) would certainly be a major first step towards a substantial reduction in the emission of greenhouse gases (GHG) from electricity generation in Guyana. AFHP, or any optional hydropower project, alone, would not be sufficient for achieving "some" 100% renewable energy use by 2025. Predicted demand (base case)¹³ in the DBIS system in 2025 is 1503.5 GWh and peak power demand 229.9 MW. Annual net output at AFHP powerhouse is estimated at 1,090 GWh in average, (844 GWh in the driest year). Maximum power available from AFHP at the delivery point in Georgetown is about 154 MW.

In order to achieve "some" 100% renewable energy use by 2025, therefore a second hydropower project of a size comparable to AFHP, will have to be commissioned by 2025, or as an alternative, other kinds of renewable generation facilities will have to be realised in addition to AFHP for covering the balance between energy demand and the power delivered by AFHP.

4.1.1 Power Generation System Expansion

Development scenarios presuming 100% renewable generation by 2025 and beyond have not been included in the two generation expansion studies carried out lately:

- (1) "Initial Study on System Expansion of the Generation & Transmission System" of July 23th 2014 and
- (2) "Guyana's Power Generation System Expansion Study" of June 2016.

The June 2016 Study assumes Amaila Falls commissioned in 2021. With a required construction period of 42¹⁴ months, from EPC Contractor's Notice to Proceed to Tests on Completion accomplished, Notice to Proceed will have to be given in January 2018 to achieve Start Operation by July 2021. That means 13 months left (from December 1st 2016) to perform all preparations from decision to resume project preparations to financial closing. We do not find this time frame realistic. Our time estimate as per today is that 3 years, instead of 13 months, would be required.

Both recent Generation System Expansion studies include AFHP as a main component in the least cost alternative for generation expansion. Considering Guyana's large untapped potential for hydropower, and two other hydro projects in the June 2016 study showing about the same specific development cost as Amaila Falls, it is surprising that none of the studied development alternatives in 2014 and 2016 includes more than one hydropower plant (AFHP). On the contrary, both studies conclude that further expansion of the base load generation capacity after 2025 should be covered by increased use of thermal power. The 2014 study suggests introduction of coal fired plant as least cost alternative for

¹² On page 8 of the LCDS document of March 2013 is stated: "It (Amaila Falls) will eliminate at least 92% of Guyana's energy related greenhouse gas emissions, ---". On p 21: "Simultaneously, it (Amaila Falls) will enable Guyana to switch from nearly 100% dependence on fossil fuel-based electricity generation to nearly 100% clean, renewable energy supplies- ". Such commitment, however, is not incorporated as a basis for the two recent studies on generation system expansion: (1) "Initial Study on System Expansion of the Generation & Transmission System" of July 23th 2014 and (2) "Guyana's Power Generation System Expansion Study" of June 2016.

¹³ Source: "Guyana's Power Generation System Expansion Study", June 2016

¹⁴ Source: IE's assessment in Section 9. Review of Schedules. Norconsult supports IE's assessment on this point.

expansion after 2030, while the most recent study report of June 2016 suggests bagasse and natural gas fuelled plant and the existing oil fired plants at this stage converted to be fuelled by natural gas. It is our conclusion that both recent reports are ignoring Guyana's commitment towards renewable energy generation.

Guyana, in order to adhere to its commitment to complete transition to renewable energy, needs in parallel with the implementation of AFHP, to start the planning of its second hydropower project intended for bulk supply to GPL's interconnected grid. It may take 3 – 4 years to: (1) do a screening study for identifying candidates for a least cost study at an updated pre-feasibility study level for selecting the next hydropower project to be constructed after AFHP, and (2) thereafter carry out a feasibility study for the selected project.

4.1.2 Customers on Isolated Grids

Two delivery points for the AFHP power are foreseen, at Linden and at Georgetown. To receive power from AFHP the customers therefore have to be connected to either the Linden grid or to the DBIS system.

For fulfilling the goal of some 100% renewable energy use by 2025, customers currently isolated from the two grids need to be: (i) connected to the Linden/ DBIS systems; or (ii) existing oil fired plant that will remain isolated from the interconnected grids, will have to be substituted by biomass fired plant, mini hydro or wind farms. Solar panels, wind mills and micro hydro are solutions for bringing electricity to small, isolated communities presently without electricity. The LCDS document reports that an ambitious program has been ongoing during recent years for bringing emission free electricity supply to small, isolated communities in the hinterland. This is a good initiative, but is not an alternative to developing Amaila Falls or another hydropower project of similar capacity.

The most favourable option for each isolated customer or community will depend on the size and location of the community, distance to connection points to the Linden/ Georgetown system, distance to suitable sites for mini-/ micro hydro etc.

In 2015 the total peak demand in four isolated systems was 7.5 MW¹⁵ (not occurring simultaneously). These systems are not planned to be connected to the DBIS system.¹⁶

For reaching a goal of 100% GHG emission free (or emission neutral) energy use by 2025, a systematic plan¹⁷ is required for the future solution for the currently isolated users, including a committed time schedule for its implementation within 2025.

4.1.3 Need for Back-up Generation Capacity

The live storage capacity in the AFHP reservoir is limited. The operation of AFHP will therefore follow a next to run-of-river pattern. The inflow estimate to the AFHP reservoir in the dry months¹⁸ is uncertain. It is clear, however, that the low season inflow will not be sufficient for continuous full capacity generation. That means additional generation from other sources will be required in the dry season from a certain year as the demand is growing, possibly already from the year of commissioning of AFHP. The last available review of the hydrology and production potential¹⁹ presented in 2011, deems the factor 0.3 used for transposing average monthly flows at Kaieteur falls to inflow to AFHP reservoir as reasonable, but highlights all sources of uncertainty connected to this assumption. On the same basis the IE Due Diligence Report of 2013 opines that the inflow to AFHP may be grossly underestimated, by more than 20% in average and more than 30% in the dry season. If the IE Engineer is right, the need for back-up capacity for the dry season may be reduced during the first years of operation.

Until a new evaluation based on later years flow measurements, comprising simultaneous measurement at the AFHP site and at Kaieteur Falls, may conclude that the dry season inflow to AFHP has been

¹⁵ Source: GPL, August 2016.

¹⁶ Source: GPL, August 2016.

¹⁷ We have not found that such planning is included in the scope of the ongoing IDB supported "Power Utility Upgrade Program" for GPL.

¹⁸ See separate sub-section on hydrology

¹⁹ Source: "Amaila Falls Hydropower Project Hydrology Review, Draft Report, June 2011, Halcrow Group Limited"

underestimated (as the IE's report indicates), it is our opinion that assessment of the need for back-up generation capacity should be based on the hydrology of the Feasibility Study and the review of the same in 2011.

The existing, most efficient thermal plants, including the existing 30 MW plant fired by bagasse, may serve as back-up capacity in low flow periods. Most probably some of the needed back-up capacity plants are still to be fuelled by diesel oil or HFO after the commissioning of AFHP.

The commitment of "some" 100% emission-free/renewable energy use by 2025 therefore may not be fulfilled, especially if the increase in demand will follow the path indicated in the Generation System Expansion Study of June 2016. To fulfil such commitment the required back-up thermal plant capacity will, if technically and logistically feasible, have to be switched from oil to biomass fuel. Alternatively, new thermal plant fuelled by biomass, PV solar facilities and/ or wind farms have to be installed at feasible locations. To maintain 100% emission-free/ renewable energy use any mismatch developing between demand and available emission-free/ renewable generation capacity would have to be solved by load shedding.

Alternatively, 100% emission-free energy use in 2025 could be achieved by implementing a second hydropower project by that time with a seasonal reservoir large enough for maintaining most of the production capacity during dry periods. We are not aware whether a site may exist with a potential for a large, environmentally acceptable, seasonal reservoir.

Development of smaller run-of-river hydro may reduce the dependence on thermal generation as the demand grows beyond AFHP's capacity, but will not be a solution to achieve the "some 100% emission-free goal" as run-of-river projects will not contribute much in the dry season and not reduce the need for back up capacity in the dry months.

Reliable supply combined with lower tariffs will certainly attract industrial investment and thereby accelerate growth in consumption. To maintain 100% renewable energy use, new emission free, or emission neutral, generation capacity will have to match the growth in demand.

In the Annex to Loan Agreement of October 2014 between IDB and Guyana on the Power Utility Upgrade Program, is referred to "GPL's Development and Expansion Programme (D&E)". If not already done, this expansion programme will have to be co-ordinated with GOG's commitments made for emission free generation by 2025 (and beyond).

4.2 AFHP's Contribution to Reduced GHG Emissions

Norconsult's TOR include the following statement and task description:

- "As outlined in the LCDS (for Guyana), AFHP was estimated to reduce 92% of Guyana's energy related emissions from energy generation for the grid"

Page 8 of the LCDS document of 2013 includes the following statement: "--- It (AFHP) will eliminate at least 92% of Guyana's energy related greenhouse gas emissions, and this will likely make Guyana the world's number one user of renewable energy by 2017."

Sithe Global's power point presentation on AFHP to the Guyanese National Assembly of August 2013 includes the following statement:

- (After implementing AFHP) "-----Greenhouse gas emissions from electricity generation will be reduced by nearly 90%"

Norconsult has not performed its own independent study of AFHP's contribution to reduced GHG emissions. Our review of the above statements is based on the below document provided by IDB:

- "Technical Memorandum. Supplemental Detailed Analyses of Greenhouse Gas Emissions" of June 2013 prepared by Exponent.

This document deals with three aspects of changes in the GHG emissions related to AFHP:

- Clearing of vegetation in the corridors for the transmission line and access road
- Creation and operation of the hydropower reservoir
- Reduced GHG emissions due to displacing GPL's current fossil-fuel powered electric generation

Emissions to the atmosphere caused by other construction activities are not discussed in Exponent's Memorandum.

The two first bullet points include Exponent's assessment of emission to the atmosphere, which is caused mainly by decay of forest and vegetation. These emissions are largest at the time when the areas are cleared, and will thereafter decrease gradually year by year until the whole stock of CO₂ equivalents in the decaying material has been released.

As an example: if all cleared wood and vegetation in the road and transmission line corridors are left for natural decay, Exponent estimates emission of CO₂ equivalents to the atmosphere to 126,332 tons the first year after deforestation. In year 20 the amount is estimated at 4,997 tons.²⁰ The actual total and annual figures will depend on the chosen approach in the cleared areas, whether usable commercial timber is sold, and whether vegetation is burnt instead of being left for natural decaying. In any case the emission to the atmosphere will gradually decrease and after a number of years the annual emissions will be insignificant.

Therefore the two first aspects will produce GHG emissions, which are presumed to be highest the first year after deforestation is completed and then be gradually reduced over the years as the stock of CO₂ equivalents is released to the atmosphere. Exponent presumes, however, that operation of the hydropower reservoir will establish continuous emission of CO₂ equivalents at a higher level than for natural pre-AFHP conditions in the Amaila and Kuribrong Rivers.

The amount of reduced GHG emissions due to displaced fuel fired generation will vary in accordance with AFHP's actual generation, which will depend on the hydrology (inflow to the reservoir) and GPL's dispatch capacity.

For year one Exponent's figures show GHG emission to the atmosphere from decaying and/or burning of the cleared vegetation and from operation of the reservoir larger than the reduced emissions due to displaced fuel fired generation the same year. Therefore, the statement: "AFHP was estimated to reduce 92% of Guyana's energy related emissions from energy generation for the grid", can only be reached after a certain number of years after most of the CO₂ equivalents from decaying vegetation have been released.

When comparing the effect of AFHP with the avoided emissions from the same amount of energy produced by existing thermal plants, the figures in the Exponent Report indicate that in year 12 after commissioning of Amaila Falls the emissions are reduced by 92% and for later years even more. Since the operation of the reservoir itself is supposed to create more emissions on a permanent basis than the river system under natural conditions, 100% reduction will never be reached.

The access road has already been constructed. The resulting GHG emissions from decaying vegetation have started and will be significantly reduced before the commissioning date of the plant. Therefore, in reality, there may be a positive reduction in GHG emissions already from the first year of operation and 92% reduction will occur earlier than after 12 years.

Anyway, the statement: "As outlined in the LCDS, AFHP was estimated to reduce 92% of Guyana's energy related emissions from energy generation for the grid", needs a more precise definition. By this short wording one may think that AFHP alone would reduce the total GHG emissions from Guyana's energy production by 92% on a permanent basis. This will not be the case and cannot be concluded from the Exponent Report, which only relates to the amount of Guyana's energy generation actually substituted by AFHP.

²⁰ Source: Exponent Study. In year 30 the emission would according to Exponent's formula be reduced to 775 tons (or insignificant).

The statement also needs to be referred to a certain year after the commissioning of AFHP, after the actual construction programme for AFHP has been settled.

Exponent's memorandum does not consider emission caused by diesel generators and excavation and transport equipment during the period of construction. However, with the very significant total emissions estimated as a consequence of forest clearing and reservoir operation, the short period of emissions from the construction activities will be of less importance.

For reasons explained in Sub-section 4.1, any reference to how large percentage of GHG emissions AFHP may substitute can only be related to the amount of energy production AFHP is actually substituting in the interconnected Linden/ DBIS system.

5 HYDROLOGY

The hydrology for Amaila Falls Hydropower Project is not very well established since continuous series of direct flow measurements in Kuribrong River at the project site do not exist. Flow records from the gauge station at Kaieteur Falls in the neighbouring Potaro River provided the basis for the Feasibility Study in 2001, as well as for later stages of project planning. For simulation of energy production at AFHP average monthly flows at Kaieteur Falls for the period 1950-90 have been used with a fixed transposition factor of 0.3.

Simultaneous flow measurements were carried out in Kuribrong River at Amaila Falls project site and at Kaieteur Falls in June-July 1975 (pre-feasibility study phase) and in June-August 2001. These measurements were used for selecting the transposing factor of 0.3. The records during these brief periods of measurement showed great variation in the ratio between the simultaneous flows in Kuribrong River at Amaila Falls and in Potaro River at Kaieteur Falls.

The measurements in June – August 2001 showed a variation in the different 10% percentiles (10% through 90%) of the monthly average flows in the range 0.276 – 0.439, with a median factor estimated at 0.383.

The Halcrow Group's Hydrology Review Report of June 2011 indicates the selected factor 0.3 to be somewhat conservative (on the safe side) as regards the production potential. The same view, even stronger, especially in periods of low flow, is opined in the IE's Due Diligence Report of 2013.

A conservative transposing factor (0.3) and the moderate installed capacity compared to the medium inflow to the reservoir means that the risk for not achieving the foreseen production potential is low. Therefore the hydrological uncertainty of having scarce series of direct flow measurements cannot be concluded to be a threat to the soundness of the project.

For reducing the present hydrological uncertainty, which is especially desirable in the low flow season, longer periods of direct measurements in Kuribrong River at the project site are required. The main benefits would be verification of the believed underestimate of the water flow in the dry season and thereby more reliable estimates of the low season energy production and improved basis for planning the required low season back up capacity.

Supported by IDB, SG started a program for continuous simultaneous measurements in 2011 at Amaila Falls and Kaieteur Falls. This program was discontinued in 2013 after SG withdrew as sponsor. A planned review of the hydrology based on the additional data acquired so far, is suspended.

We recommend that the programme for continuous water flow measurement is resumed as soon as possible and before a new main sponsor would be ready to take the front seat. 2-3 additional years of continuous flow data would provide a more reliable basis for an updated energy production simulation and thereby reduce the risks for both parties related to the PPA. Based on the same improved flow data the design flood capacities of the dam spillway and flood levels of the reservoir should be reviewed as well.

In addition to flow records we recommend a continuous sediment sampling program of at least one year's duration to get a picture of the seasonal variation. As per today only a limited number of spot measurements of sediment transport exist and the project design does not include any facilities for future sediment handling. Probably, siltation of the reservoir may not create any problem during the first 20 years of plant operation. Sedimentation may therefore not be a concern for the private investor in the BOOT perspective. GPL, as operator beyond the BOOT period, should pay closer attention to this issue.

Direct flow records in the period until commissioning of the project would provide a valuable data base for planning the plant operation during the first years of operation and as a reliable basis for deciding on the total installed capacity in a possible later second stage development.

6 ENVIRONMENTAL ASPECTS

6.1 Background

The Project has been studied extensively with the first EIA produced in 2002²¹. Further studies ensued thereafter including an ESIA produced in 2011²² and subsequently updated through a series of addendums and specialist studies up until 2013.

The Project Direct Area of Influence (DAI) and the Indirect Area of Influence (IAI) were defined in the 2011 ESIA. The terrestrial portions of the Project DAI include the directly affected area of the hydropower scheme plus 100 m on each side of the transmission line and 500 m on each side of the access road (approx. 207 km long). The DAI also includes the area to be occupied by construction camps, service roads, borrow pits, surplus material deposits, and other construction support infrastructure, plus a 100 m buffer surrounding these areas.

In the case of aquatic ecosystems, the DAI includes the Amaila and Kuribrong river reaches upstream of Amaila Falls, along the about 23 km² full segment to be flooded by the reservoir plus 1 km upstream, the reduced flow reaches between the dam and the tailrace channel discharge, and the Kuribrong River downstream of the discharge, along the reach terminating at the confluence with the Potaro River. For the cumulative impact assessment update of 2013 the Essequibo River was also included in the assessment area to the extent the access road provides new or improved access points to the Essequibo River.

Extensive baseline studies have been undertaken to characterise the bio-physical and socio economic and cultural context of the Project. Following from this an assessment of potential impacts has been made and management and mitigation recommendations and plans proposed.

The 2011 ESIA report format and content (including subsequent updates) conform to international best practice for environmental and social impact assessment and provide a good platform from which to draw conclusions as to the environmental acceptability of the Project.

6.2 Environmental and Social Risks

The Project is located in an area of high terrestrial and aquatic biodiversity and thus merits concern.

In terms of terrestrial biodiversity, however, impacts are reduced given the relatively small area of land-take for the hydropower scheme.

Significant risks, though, do exist due to potential secondary impacts from non-Project related activities exacerbated particularly by the construction of a long access road. The GOG and IDB recognised these risks and agreed on an Access Road Control Framework in 2010, which prohibits the use of the road for mining and forestry commercial activities and all mining and forestry activities in a 200 m buffer on each side of the road. However, this Control has not been effective and since the construction of the access road started there has been a considerable increase in mining activities and deforestation observed along the route which will inevitably increase unless a more rigorous set of controls can be put in place. Since the road already has been constructed, it cannot be considered as part of the future hydropower project, and therefore the impact of the road should not be considered when deciding whether to go ahead with the development of the Project. However, the Project may facilitate the introduction of the Access Road Control Framework, which could limit the negative environmental impacts of the road.

Risks and uncertainties also exist concerning the aquatic biodiversity in the Project area and the upstream and downstream. Initially studies found four endemic fish species above the falls; 3 of these fish species use a range of habitats dispersed through the watershed. However, 1 fish species

²¹ Ground Structures Engineering Consultants Inc. (GSEC)

²² Prepared by the international firm Exponent

(*Characidium amaila*) was found only in five rapids (and a significant area of these rapids will be lost if the Project is constructed).

Although the most recent studies indicate that the overall risk to aquatic biodiversity outside the Project DAI is likely to be low some uncertainties remain concerning fish species in the DAI.

With regard to the physical and chemical impacts on the aquatic environment, assessments in the ESIA of 2011 of the downstream impacts identified the following environmental stressors as the primary issues of concern during Project construction and operation:

- Water released from the Powerhouse will have levels of dissolved oxygen (DO) that are lower than ambient levels in the river;
- Water released from the Powerhouse will have levels of hydrogen sulphide (H₂S) that are higher than ambient levels in the river;
- The natural hydrological cycle will be altered due to dampening of seasonal and short-term natural fluctuations by operation of the Powerhouse;
- The natural hydrological cycle will be altered by reservoir filling; and
- The river could be subjected to higher sediment loading during construction from land clearing and reservoir clearing activities (approx., 23 km² for the reservoir).

In the event that reservoir clearing takes place and most biomass is removed prior to reservoir filling then water quality impacts will not be significant. The system was modelled with scenarios using low, average, and high flow years with complete vegetation removal and scenarios with average flow year with no removal and partial removal of vegetation were simulated in the reservoir, in the segment 155 km downstream of the reservoir, and in the segment between the dam and the Powerhouse.²³ Water quality in the reservoir is greatly influenced by the water quality of inflows because reservoir residence time is short. The simulations indicated that the reservoir is well mixed, and despite some areas of low DO concentrations, a hypolimnion would not exist. High CO₂ concentrations were due to high CO₂ river inflows. A large proportion of the CO₂ is emitted from the reservoir, with the remaining mostly passing through the dam. Both H₂S and methane concentrations were very low and will not have downstream impacts. Although there will be some concentrations of inorganic and methylmercury in reservoir water and aquatic biota, there would be no significant ecological risk because concentrations in the watershed are low and the reservoir is well mixed.

In terms of the seasonal River flow regime and effects on downstream habitats; due to the similarity in hydrographs representing conditions before and after Project completion, it is likely that downstream aquatic habitats will not be adversely affected from any changes induced by the Project to the seasonal flow pattern. Given the historically natural flashiness of the Kuribrong River in the DAI, the anticipated persistence of intra-annual flood-pulse peaks and base-flow frequencies, and the minimal areal extent of off-channel floodplain habitats throughout the Kuribrong watershed, it is anticipated that alterations of seasonal flow patterns in the Kuribrong River downstream of the Powerhouse will thus also have minimal impacts on downstream fish communities.²⁴

Additionally, the effect of flow regulation on seasonal flow patterns in the Kuribrong River will decrease with distance from the Powerhouse with additions of unaltered flow inputs from tributaries. At 20 km downstream modelling shows that better concordance with natural flows is apparent at both the onset and decline of the main rainy season (April – May and August – September) and with the exception of the first 30 days of the year and a period of about 2 months at the end of the main rainy season, discharges are not held constant at 51 m³/s. At 50 km and 85 km downstream, spikes in post Project flows more closely match natural fluctuations over increasingly greater portions of the year; however, rather abrupt drops in flow from about 51 m³/s to natural base flows of about 10–20 m³/s are still expected about the end of January, beginning of May, and end of September at all locations. However, these drops are less severe in magnitude than similar drops in flow under natural conditions thus should not stress the ecosystem unduly.

To account for times when the Project is not spilling or releasing water through the turbines due to water conservation or maintenance reasons, a minimum environmental flow (MEF) of 1 m³/s is suggested for the Project. The MEF is required to maintain the aquatic ecosystem downstream in the event of short

²³ Exponent, Technical Memorandum Supplemental Water Quality Report, June 2013

²⁴ AFHP, Supplemental Assessment of Project Impacts in the Downstream Kuribrong River, June 2013

duration disruption to River flow. However, the selection of the MEF quantity of 1 m³/s is not clearly justified in the Project ESIA or supplementary documentation. Unless it can be demonstrated with greater certainty that the MEF selected is sufficient to maintain the downstream ecosystem, there is a risk that the amount will be insufficient and result in significant damage to the natural aquatic environment in the downstream area before tributary inflow can assist to ameliorate the situation.

During the reservoir filling period the MEF proposed is 6.8 m³/s (the lowest 7-day average flow expected to occur in a 10-year period at the powerhouse location). As for the MEF proposed during operation; the selection here also needs to be more clearly justified.

Variation in release patterns will also create change in water level elevations that could potentially impact on human activities (e.g. mining through river dredging, fishing, and transportation of goods and people). However in this case there is little risk of the Project resulting in significant disruption of human activities, or creating hazardous situations due to rapid fluctuations in water levels due to routine Project operations in the Kuribrong River downstream of the Powerhouse. It is assumed that during normal operations, changes in generation will likely be in the order of 5–10 MW over 15 minutes. This would be equivalent to a 1.7 - 3.3 m³/s change in flow or 2.5 – 5 cm change in tailwater elevation. Such a change would not have any appreciable effect downstream. Overall, the maximum possible variation in elevation of the tailwater due to regulation is 85 cm but this would not be a common occurrence.

Based on a review of the 2011 ESIA, from the social perspective there is no existing permanent settlement at the Project site or periphery, although at least three sites of cultural/landscape significance have been identified by the Chenapou community. Natural resource use in terms of hunting and fishing in the Project area is low. Kaburi Reservation and Butakari work camp are the nearest settlements to the DAI (record from 2011). Concerns are again associated with the access road; forest edge effects and barriers to movement of fauna caused by deforestation and habitat disturbance which will reduce opportunities for hunting traditionally practiced by some Amerindian communities in the area. However, the primary source of income for these communities as reported is through agriculture and mining thus there is unlikely to be a significant negative effect on current livelihoods.

Although the direct impacts of the project on the socio-economic and cultural environment are unlikely to be significant, the indirect effects associated with increased mining and logging along the access road may be of sufficient concern to trigger the Indigenous Peoples safeguards policies of the major international financial institutions. From a consultation perspective, the degree to which local communities and key stakeholders perceive they have been involved in an inclusive and participatory process cannot be ascertained with the documentation currently available. It is understood, however, that some discontent among affected local communities may have contributed on the vote in the Parliament in August 2013. We therefore recommend the consultation program with affected local communities to be reviewed, updated and repeated in parallel with resuming project preparations.

6.3 Key Conclusions

The 2011 ESIA including Addendum Nos 1 and 2 indicate that the Project is environmentally and socially acceptable provided certain key management and mitigation plans are developed and implemented. As part of the management and mitigation a more robust assessment of the proposed MEF is also recommended (e.g. by applying the DRIFT Model²⁵) with adjustments to the suggested flow if necessary.

Of critical importance will be the development and full implementation of an access control plan that will minimise the use of the new Project access road and transmission line corridor for activities such as mining and logging.

The biodiversity offset plan drafted in 2013 is to be completed and implemented as an additional management measure that looks to protect similar areas of habitat elsewhere in Guyana. Some residual impacts to biodiversity will remain after construction and into operations that cannot be fully avoided, mitigated, or restored at site, including:

²⁵ DRIFT (an acronym for Downstream Response to Imposed Flow Transformations; King et al. 2003; Brown et al. 2010)

- conversion of natural habitat (forest and river) due to flooding of the reservoir and construction of the dam above the escarpment;
- conversion of natural habitat (forest) due to the construction of (i) the powerhouse and related facilities, (ii) the access road, and (iii) the transmission line corridor, all below the escarpment;
- degradation of the mist zone habitat in the vicinity of Amaila Falls due to the changed flow regime in the river;
- degradation of river habitat both up- and downstream of Amaila Falls through decreased and/or modified flow regimes; and
- fragmentation of natural habitat due to the road and transmission line.²⁶

²⁶ Draft Biodiversity Offset Plan (Plan) prepared jointly by AFHI and the GOG taking into consideration input from Conservation International (CI 2013).

7 DESIGN ISSUES

7.1 Natural Conditions for Hydropower Development at Amaila Falls

The most favourable natural features of the Amaila Falls site for the planned hydropower project are: (i) the river gradient provides an inherent gross head of about 350 m over a river stretch of only about 3 km; (ii) the geology seems generally favourable for underground works, especially in the igneous rocks underlying the sedimentary rocks on top, and (iii) the planned installed capacity is small compared to the mean water flow in Kuribrong / Amaila rivers at the project site.

A drawback is the topographic profile at the dam site, which requires a very long dam for creating even a quite modestly sized live reservoir. The seasonal regulation capacity of the reservoir is therefore insignificant. The height of the dam adds only about 5% to the gross head of the plant, while the dam cost represents about 29% of the total EPC Contract Price²⁷ for the Power Plant.

The regular operational pattern of AFHP will be close to a run-of-river scheme with spill of water over the dam crest much of the time, while the plant at the same time may run at full capacity. In periods of inflow less than required for continuous operation at full capacity, the reservoir storage volume is sufficient for any rational mode of peaking operation of the plant.

Another natural drawback is the longitudinal topographic profile of the tunnel routing with an abrupt escarpment just beyond midway in the alignment. This creates a horizontal distance of about 1.2 km from the vertical pressure shaft inside the mountain ridge to the powerhouse at the end of the tunnel, which makes the pressure shaft and pressure tunnel quite expensive plant components. This is further commented under sub-section 7.5.

A financial hurdle, for realising AFHP, is the 270-280 km long transmission line required from the project site to the main dispatch centre in Georgetown. The cost structure of the EPC Contract shows that the line adds about 44% to the construction costs of the power plant itself, which again is reflected in the energy tariff.

7.2 Possible Future Extension of Amaila Falls Hydropower Plant

As Guyana's power demand is growing over the years, the long term optimum installed capacity at Amaila Falls in a developed power market would probably be higher than the 165 MW initially planned. In the future, therefore, extension of the installed capacity in Amaila Falls may be considered and compared in a least cost expansion perspective together with other hydropower sites with acceptable environmental and social impacts.

We envisage a possible second stage extension as a separate plant located in parallel with the first one. A major advantage of such overall layout is that there is no need to decide now on what shall be the total future installed capacity. Secondly, upfront investment in the first stage on works that will be useful only in the future will be minimal. As preparatory works for a possible second stage, only works required for avoiding later interruption of ongoing plant operation should be considered.

If water flow measurements in Kuribrong River is resumed in the near future as part of the project preparations, and with a time perspective of at least 10 years between the commissioning dates of the two stages, several years of river flow records would be available for reliable optimisation of the final installed capacity.

Provided the same reservoir limits are maintained after a future extension of the capacity, the marginal environmental impacts would be insignificant.

²⁷ Reference: EPC Contract signed with CRFG in 2012

7.3 Independent Engineer (IE) Due Diligence Technical Evaluation Report

A key document for Norconsult's study has been the "Independent Engineer (IE) Due Diligence Draft²⁸ Technical Evaluation Report" dated April 29th 2013. This report was made by Tractebel Engineering in a joint agreement with IDB and SG. The report exists in draft version only and, as such, will have to be construed as opinions of the hired consultant alone.

The IE report appreciates the status of project preparation in early 2013, within the frame of a signed EPC Contract, and other permits and agreements having reached advanced stages of preparation and assumingly general consensus between the parties. Consequently, any suggestion by the IE for changes and adjustments to the project design or the provisions of the GL, IA or PPA documents would have had to be negotiated as amendments to the existing EPC Contract and to the various other advanced stage draft agreements. It seems that this may have refrained the IE from highlighting a few features of the design that in our opinion should have been elaborated further before defining the set of "Owner's Requirements" for the design that were the basis for the EPC tendering process. Instead IE pinpoints various design issues that the EPC Contractor would have to clarify or solve during the course of construction. Some of them, and especially the one mentioned in sub-section 7.5.2, would probably have turned out as a headache later between the EPC Contractor and AFHI.

Assuming that reopening the negotiations with China Rail is not the way forward, the situation today is different. With a new EPC tender process ahead and AFHI's most important permits and other agreements expired, the project is back to a stage where changes or improvements to the project design can be incorporated in a revised technical "Owner's Requirements" document without complicating any assigned contracts.

The technical parts of the IE Report are based on the design²⁹ defined as "Owner's Requirements" in the EPC Contract with China Rail.

The IE Report also comments on and gives suggestions to the EPC Contract itself and on the interim version of the "Generation Licence" (GL), and on the initialled versions on the "Implementation Agreement"(IA) and the "Power Purchase Agreement" (PPA).

It is our overall judgement that the IE Report is a thorough document covering all major issues of relevance and we concur with most of its conclusions and recommendations.

A majority of the comments made by the IE in 2013 to the project design and to the various permits and agreements would be as valid under the changed circumstances and should be carefully considered if resuming project preparations under a new sponsor regime.

Although the geological conditions appear generally favourable for underground works, we support the IE's suggestion that some additional site investigations should be made in order to reduce the remaining uncertainty. Instead of having this done by the EPC Contractor after contract signing, this should be done in advance and conclusions be reflected in a revised version of the EPC tender documents. Especially, we would recommend seismic refraction profiling along major parts of the dam alignment and along certain stretches of the headrace tunnel, supplemented by a few additional core drill holes at key locations for control.

7.4 Transmission Line

Several issues should be looked more closely into, including the transmission line, in order to possibly arrive at a project and development model more favourable, to GOG and for GPL as power off-taker, and in the long term perspective of the Guyanese power system.

²⁸ The AFHI file released to Norconsult includes a draft version of IE's report. We understand that the IE's assignment was suspended before a final version was issued.

²⁹ The design reviewed in the IE's report is presented on 33 drawings filed in the Norconsult Data Room under folder: 6 EPC/ 2 EPC Exhibits/ Amaila Falls EPC/ Exhibit A Workscope/ Drawings/ Section 8 Owner's Requirements-Revised Drawings March 2011. These drawings present the project to sufficient detail that would be required as basis for a competitive EPC bidding process. As presented later, it is Norconsult's opinion that "Owner's Requirements" for the overall plant layout have been decided before important operational capabilities of the plant have been sufficiently analysed.

The 270-280 km long transmission line required from the project site to the main dispatch centre in Georgetown, including the intermediate substation at Linden, constitutes a significant portion of AFHP's construction costs, which explains much of the reason for the relatively high electricity tariff to GPL.

Considering need for transmission from other hydropower development in the same region in the future, as well as a possible extension of Amaila Falls, it should be considered whether the capacity of the line should be upgraded and the line itself be regarded as a backbone in a future transmission system intended for several projects rather than only as a component of AFHP.

Among possible developments in the future that could be connected to the same line is the Tumatumari Project (152 MW) located at about 70-80 km distance from Amaila Falls towards Linden. In the Generation System Extension Study of June 2016 the specific development cost of the Tumatumari Project is estimated to be about the same as for AFHP.

Upgrading of the capacity of the line would mean higher investment cost at the first stage, but large cost saving, including less need for clearing of new corridors for parallel lines, for other projects that could be connected to the line later on.

As part of a backbone structure in a future larger system, the transmission line may be realised as a separate project in the public sector with more favourable financing than for the BOOT arrangement of the power plant. To secure timely execution of the transmission line, co-ordinated with the commissioning of the Amaila Falls power plant, construction of the line could still be part of the EPC Contract for AFHP, but the line being taken over by GPL at completion, instead of by the SPC. Operation of the line could either be by AFHI over a certain number of years in an agreement with GOG, or by GPL from the beginning.

7.5 The Overall Project Layout and Design

7.5.1 General

Considering the longitudinal profile of the waterway and apparent suitable rock conditions, we find it surprising that an underground powerhouse is not mentioned anywhere as a project layout alternative, except a short note in the IE's report³⁰ stating that more usually a powerhouse underground would have been expected under natural conditions as encountered at Amaila Falls. We agree with this observation.

The IE notes further in its report³¹ that the Owner's Requirements do not include a minimum requirement to overall plant efficiency, which includes the hydraulic losses in the waterway. The power plant is required to yield a certain output (MW) at a certain headwater level with no maximum figure set for the corresponding turbine water flow. Therefore the EPC Contractor could choose to diminish the cross area (diameter) of the tunnels in order to save cost and compensate by increasing the water flow. This would mean less energy production of the same amount of water and thereby a less efficient utilisation of the Amaila Falls as a hydropower resource. We would comment that 19 m headloss³² in an about 3 km long headrace tunnel is higher than would be expected for a hydropower plant designed by traditional procedures for hydraulic optimisation, especially for a plant with as high plant factor³³ as AFHP. As explained in sub-section 7.5.2. below, the dimensions described for the pressure shaft and pressure tunnel are also not sufficient for satisfying requirements for regulation stability.

No sediment handling methodology is reflected in the design of the plant. It is only stated that the natural sediment transport in the two rivers is limited and that the activities in the upstream catchments should be restricted to avoid any future compromising of this currently favourable situation.

³⁰ Ref: IE Report page 60. 4.3.5.1 "General comment on the waterway profile"

³¹ Ref: IE Report page 61-62. 4.3.5.3 "Head Losses"

³² At full plant capacity

³³ Annual hours running at full capacity

7.5.2 Requirement for Regulation Stability

After its commissioning AFHP will be the dominating generating facility in the Guyanese power system and AFHP will have to satisfy fully the conditions for frequency regulation stability for "island" operation³⁴.

Due to the topography (longitudinal profile of the water way) a powerhouse located at the tunnel outlet will require an about 1540m long pressurised water conduit between the surge shaft and the powerhouse. This conduit consists of an about 310m high vertical shaft and an about 1230m long pressure tunnel. About 960m of the tunnel is assumed to be steel lined, while the rest of the tunnel and the vertical shaft are foreseen to be concrete lined.

Our hydraulic check of this system has revealed that the length of the pressure shaft and pressure tunnel, combined with the cross sections anticipated for these components, will require generating units with about 100% additional moment of inertia (GD^2) capacity compared to what would be the "natural" design for units of the actual head, size and rate of rotation. This is a much larger GD^2 capacity than can be incorporated in the rotor of the generator. A separate flywheel would be required between the turbine and the generator, which is a highly uncommon design and impractical for vertical shaft units of a size as in this case and would, if at all feasible, add substantially to the cost of the generating units. Flywheels are not indicated on the EPC Contract drawings and we cannot see that the need for it mentioned in the technical description, the Bill of Quantities or in the IE's Due Diligence Report of 2013.

A way to avoid the need for flywheels is to increase the cross sections of the pressure shaft and pressure tunnel by about 100%. This will require GD^2 capacity of the units about 30% higher than normal design and can be accommodated without adding flywheels. By this change, the cost of pressure shaft and pressure tunnel would increase by about 100%³⁵.

Our technical check on this matter is presented in short in Annex 1 to this report.

The above question has been superficially covered in the IE Report, just a comment that these issues will have to be solved by the EPC Contractor. We are of the opinion that this has to be looked closer into and the solution incorporated in the "Owner's Requirements" and updated in the bid documents before a new EPC tendering.

7.5.3 Length of Steel Lining

Considering the overburden (vertical distance from tunnel to surface) and the maximum future water pressure inside the tunnel, we consider the assumed 960m length of steel lining of the pressure tunnel as a minimum. Whether 960m is sufficient can only be documented by in situ rock stress measurements from inside the tunnel during excavation. Extension of the steel lining may also be required for controlling future water leakage out of the tunnel at crossings of faults or weakness zones.

The length of the steel lining and the criteria and test procedures for final decision on the stretch that needs steel lining, should be reviewed before a new EPC tender process.

The presently assumed length of the steel lining represents a geological risk that cannot be fully assessed in advance. To a certain degree the risk can be reduced by expensive core test drilling from the surface and down the hole hydraulic splitting tests at different levels.

The risk shearing mechanism for cost overrun related to encountered geological conditions more adverse than anticipated will have to be properly addressed in the EPC Contract and in the Power Purchase Agreement.

Alternatively, the risk could be eliminated by assuming steel lining in the whole length from the powerhouse up to the top of the pressure shaft with a substantial additional cost, which would then be reflected in the tariff from the beginning.

³⁴ AFHP will not have any support from the grid in maintaining its operational stability by load changes

³⁵ The breakdown of China Rails prices presented in the EI Report (P 136) indicates about USD 35 million in cost increase for enlarging the cross section of the pressure shaft/tunnel by 100%.

7.5.4 Bottom Outlet

The AFHP's dam has no bottom outlet. A bottom outlet will most probably be required once or more during the lifetime of the project.

The potential needs would be for complete dewatering of the reservoir in connection with repair or rehabilitation of the dam, for removal of sediments, or during the construction phase of a second stage. The requirements should be analysed in order to decide on capacity, location and dimensions of the bottom outlet and included in a revised version of the "Owner's Requirements" before inviting for the second round of EPC tendering.

7.5.5 Dam Design

The possibility of simplifying the design of the long low sections of the dam should be studied with the aim to reduce total concrete and volumes and construction costs, and the drawings representing "Owner's Requirements" being revised accordingly.

7.6 Alternative Overall Project Layouts

Because of the issues commented under 7.5.2 and 7.5.3 above it is our opinion that the overall project layout chosen as the "Owner's Requirement" for the EPC Contract may not be the optimum solution for the project.

In the Feasibility Study Report five layout alternatives were compared, all with powerhouse at surface at the tunnel outlet and the same drawback caused by long pressurised penstock/ tunnel sections. We have not found any indication in the project material that these layouts have been compared with an alternative underground powerhouse location, which could eliminate the frequency stability problem and give substantial cost saving for the tunnel system and the generating units.

It is our opinion that two alternative overall layouts should have been considered before selecting the one defined as "Owner's Requirement" for the EPC tender basis.

The main features of the alternatives would be:

Alternative 1:

Upper part of the headrace tunnel, the surge shaft and the penstock shaft as for the "Owner's Requirement" layout (EPC Contract). Underground powerhouse (with separate transformer cavern), located at a distance from the tailrace outlet that would make generating units with normal GD^2 satisfy all operational requirements.

Saving: Substantial cost saving for the generating units. Shortening of the pressure tunnel with deletion of 600-800m of steel lining, including concrete embedment. No need for extensive open pit excavation and slope stability measures for a surface powerhouse.

Additional cost: About 450 - 500m of access tunnel to the powerhouse. Powerhouse excavation. About 150m construction adit/ surge tunnel down to the tailrace tunnel in the powerhouse area. 450 - 500m of high voltage cables to be aligned in the access tunnel.

Alternative 2:

Powerhouse located underground about 1 km from the intake with no need for a surge shaft at the end of the low pressure tunnel upstream of the powerhouse. Switchyard at surface above the powerhouse with high voltage cables in vertical shaft.

Saving: Substantial cost saving for the generating units. Substitution of about 1100m of pressurised concrete lined and steel lined tunnel by a low pressure generally unlined tailrace tunnel. Deletion of the

60m high, 6 m wide, reinforced concrete surge tank. No need for extensive open pit excavation, including slope stability measures, for the surface powerhouse.

Additional cost: About 1200m of access tunnel to the powerhouse. Powerhouse excavation. About 150m construction adit/ surge tunnel down to the tailrace tunnel in the powerhouse area. 370 – 380m vertical cable shaft to surface including high voltage cables.

We may suggest that a cost study at desk level should be made of the two above alternatives before elaborating the current design taking into account the modifications described under 7.5.2/ 7.5.3 above.

8 FINANCIAL ANALYSIS

8.1 Background

In August 2013, Sithe Global presented the Amaila Falls project for the Guyana Parliament. In this presentation, the total development cost of the project was USD 858 million, of which USD 671 million were capital costs and USD 187 million were financing costs. With an expected annual generation of 1,047 GWh per year, their analysis resulted in an average electricity tariff of about 9 USc/kWh over the 20 year PPA period, and an initial tariff of about 11 USc/kWh for the first years. The project cost includes the transmission line, and the operating costs forming the basis for the unit costs include operating expenses for the transmission line.

Norconsult has received a copy of the financial model used for optimizing the financing of the project, and has adjusted the construction cost to match the one presented to the Parliament. With these adjustments, the model yields an average tariff of 9.04 USc/kWh and an initial tariff of 11.2 USc/kWh, meaning that the model seems to reflect the assumptions that were presented to the Parliament.

The main selling point of the presentation was that the fuel cost alone of the current electricity generation was 19 USc/kWh, meaning that constructing Amaila Falls would cut electricity costs by more than 50% for the energy produced by AFHP, or USD 3.3 billion over 20 years.

8.2 Review of the Financial Terms and Model

One of the review team's tasks is to consider whether there are any ways to restructure the project in order to yield a lower cost and therefore make it more attractive from the Government's perspective, as well as from potential investors' perspective.

Since payments below USD 100 million will give a better credit rating for GPL, it is fair to assume that the debt interest rates should be lower in the case with lower PPA payments. The main lenders to the project are assumed to be IDB and CDB (China Development Bank). GOG would in any case like to keep IDB as lender in order to secure a responsible and transparent implementation of the project. A requirement from the banks is that Sinasure issues a political risk insurance in case GPL is not serving its obligations under the PPA. This insurance is only valid as long as GOG issues a guarantee for the payment from GPL. Due to this link, GOG is exposed to the credit risk of GPL. In reality, GOG is already subsidizing GPL due to the high generation costs in Guyana, and in reality the exposure of GOG will be lower with AFHP place, leading to lower electricity generation costs.

The original PPA had a risk allocation which was not well balanced in the sense that several major risks were not allocated to the party who was best equipped to handle the risks. The review team is of the opinion that these risks to a large extent have to be transferred to the EPC Contractor and the Sponsor. Such transfer of risk would reduce the risk on the hand of GPL, and thus contribute to decrease the credit risk of GPL and consequently reduce the interest rate on the debt.

The access road is included in the construction budget with USD 20 million. This road has already been built and this amount is a sunk cost. This cost should therefore not be included in the investment analysis. We have therefore reduced the capital construction cost by USD 20 million in our analysis. The cost impact of required or suggested design changes in chapter 7 is uncertain and may go both ways since there are both cost additions and cost savings. We have therefore not included any extra costs in our economic and financial analyses. In order to reduce the annual payments, we have increased the repayment period of Tranche A (CDB debt) from 12 years to 15 years. Furthermore, to reflect a lower credit risk as a consequence of lower PPA payments from GPL and lower general interest rate levels, we have cut the interest rates of the debt by 1% point, and the cost of the Sinasure political

risk insurance from 8% to 6% (upfront payment). We also believe that the Sponsor’s equity return requirement of 19% is too high, and have cut it to 17%. Since GOG’s equity investment in the project is mainly financed by gifts, we have not assumed any required return on this investment (contrary to the case when Sithe Global made their presentation). With these changes in assumptions, the total project cost is cut from USD 858 million to USD 801 million.

The change in the project cost is illustrated in Table 1 below:

Table 1 Total project cost

MUSD	Original	Modified
Capital cost	680.3	658.0
Contingency	28.5	27.5
IDC	89.1	71.3
Financing fees	10.6	10.0
Sinosure insurance	49.6	34.0
Total project cost	858.1	800.7

The main financing assumptions in the original presentation and in our review are given in Table 2 below:

Table 2 Main financial assumptions

Financing assumptions	Original	Modified
Tranche A		
Interest rate	7.20 %	6.20 %
Tenure years	12	15
Fees	1.75 %	1.75 %
Tranche B		
Interest rate	8.98 %	7.98 %
Tenure years	19	19
Fees	2.00 %	2.00 %
Sinosure rate	8.00 %	6.00 %
Equity return		
GOG Equity A Contribution	0.00 %	0.00 %
GOG Equity B Contribution	0.00 %	0.00 %
Sithe Equity	19.00 %	17.00 %

The capital structure of the modified financing is given in Table 3 below:

Table 3 Capital structure

CAPITAL STRUCTURE	% Cap		
Debt Tranche A	435.6	54 %	81 % of debt
Debt Tranche B	100.0	12 %	19 % of debt
Total Assumed Debt	535.6	67 %	
Sithe Equity	125.1	15 %	47 % of equity
GOG Equity A Contribution	140.0	18 %	53 % of equity
GOG Equity B Contribution	-	0 %	0 % of equity
Total Committed Equity	265.1	33 %	
Committed Sources	800.7	100 %	

8.3 Modified Results

With the modified financing and removal of the access road construction cost, the average generation tariff has decreased from the original 9.04 USc/kWh to 7.98 USc/kWh. The initial tariff has decreased from 11.2 USc/kWh to 8.85 USc/kWh, although the number of years with the higher tariff has increased from 12 to 15. After the 20 years' PPA period, the project is returned to GOG, and the energy cost will then be 1.43 USc/kWh, which only covers operating costs and maintenance. With this suggested financing scheme, the annual payments from GPL under the PPA will be below USD 93 million in the initial years, but increasing somewhat due to inflationary adjustments of operating costs until year 15 when tranche A has been fully repaid. Under the original financing scheme, the corresponding annual PPA payments were USD 117 million, which means that the suggested changes to the financing has reduced the annual PPA payments by about 20% in the initial years.

8.4 Financial Attractiveness of the Project

8.4.1 Demand

The review team has not made any assessment of the demand forecasts, but refer to the Verlyn Klass report "Study of Alternatives" which was made in 2012. The report compares 3 different load forecasts from other sources and concludes that the peak demand in 2025 will be in the 200 – 250 MW range, and that the annual energy consumption in the same year will be in the 1250 – 1600 GWh range. Currently all electricity generation in Guyana is thermal and significantly more expensive than the estimated generation cost of Amaila Falls, and there would therefore be a need for all the power from Amaila falls in the near future (165 MW installed capacity, 1047 GWh annual generation).

8.4.2 Alternatives

The Klass report compares Amaila Falls with several other technologies and other hydropower alternatives. The conclusion for all thermal power plant alternatives using fossil fuels had a generation cost of 17 – 19 USc/kWh, which is significantly higher than Amaila Falls. Biomass had an estimated cost of only 4.4 USc/kWh, excluding the cost of the biomass. If burning waste biomass, this means that this is the least expensive option, but unfortunately there is not sufficient biomass available. In order to get

sufficient biomass, one would have to cut large areas of the forest, and this would have both a financial and environmental cost, and be in breach with GOG commitment to keep 99.5% of the rainforest intact.

PV solar and wind projects were at the time more expensive than Amaila Falls with unit costs of 26 and 14 US\$/kWh, respectively. Recent projects in other developing countries have shown that the cost of PV solar projects have dropped significantly and may now be more competitive, but from a system point of view, solar power is not sufficiently stable and can therefore not be recommended as the main source of power in the main grid. Solar may be used in off-grid areas with battery back-up and or in the main grid for generation during day-time, but it cannot function as source for base load power.

Based on this analysis, Klass concluded that hydropower was the best and least cost long term alternative for electricity generation in Guyana.

In order to assess whether Amaila Falls was the best hydropower project for Guyana, Klass made an evaluation of the known alternatives. The larger alternatives were rescaled to match the projected electricity demand in Guyana. The report summarized the scores in the following table:

Table 4 Evaluation of alternatives - Source: Verlyn Klass

Hydropower Project	Technical/Economic Preference Index	Environmental/Social Preference Index	Final Ranking
Amaila Falls	100	100	100
Kaieteur Falls	79	67	74
Turtruba	62	50	57
Upper Mazaruni	56	33	47
Arisaru	79		
Okob Blue	68		

The table shows that Amaila Falls was the most attractive project both from a technical/economical point of view and from an environmental/social point of view.

The most recent study made, “Guyana’s Power Generation System Expansion Study” by Brugman SAS (June 2016), also concludes that hydro is the lowest cost option, and that Amaila Falls is the second lowest cost option of the hydro plants included in the study, marginally higher than the Tumatumari project. The Tumatumari project, however, has a significantly lower plant load factor (50-55% vs 70-75% for AFHP), which means that more back-up capacity is needed if this project is chosen as the first hydroelectric project to be developed. The Tumatumari reservoir would inundate 6 – 20 times larger area than the planned reservoir of AFHP with more extensive environmental impacts. Furthermore, the studies for Tumatumari from the 1980-ties need to be updated to a feasibility study level, including state of the art environmental and social impact assessments. Tumatumari may therefore be better suited as the second hydropower development in Guyana as its location is suitable for sharing the transmission line with AFHP.

The results are shown in Figure 1 on the next page. Bagasse is the least cost alternative for adding new generation capacity in this study provided bagasse is available as waste material at no processing cost. Such availability of bagasse, however, is quite limited.

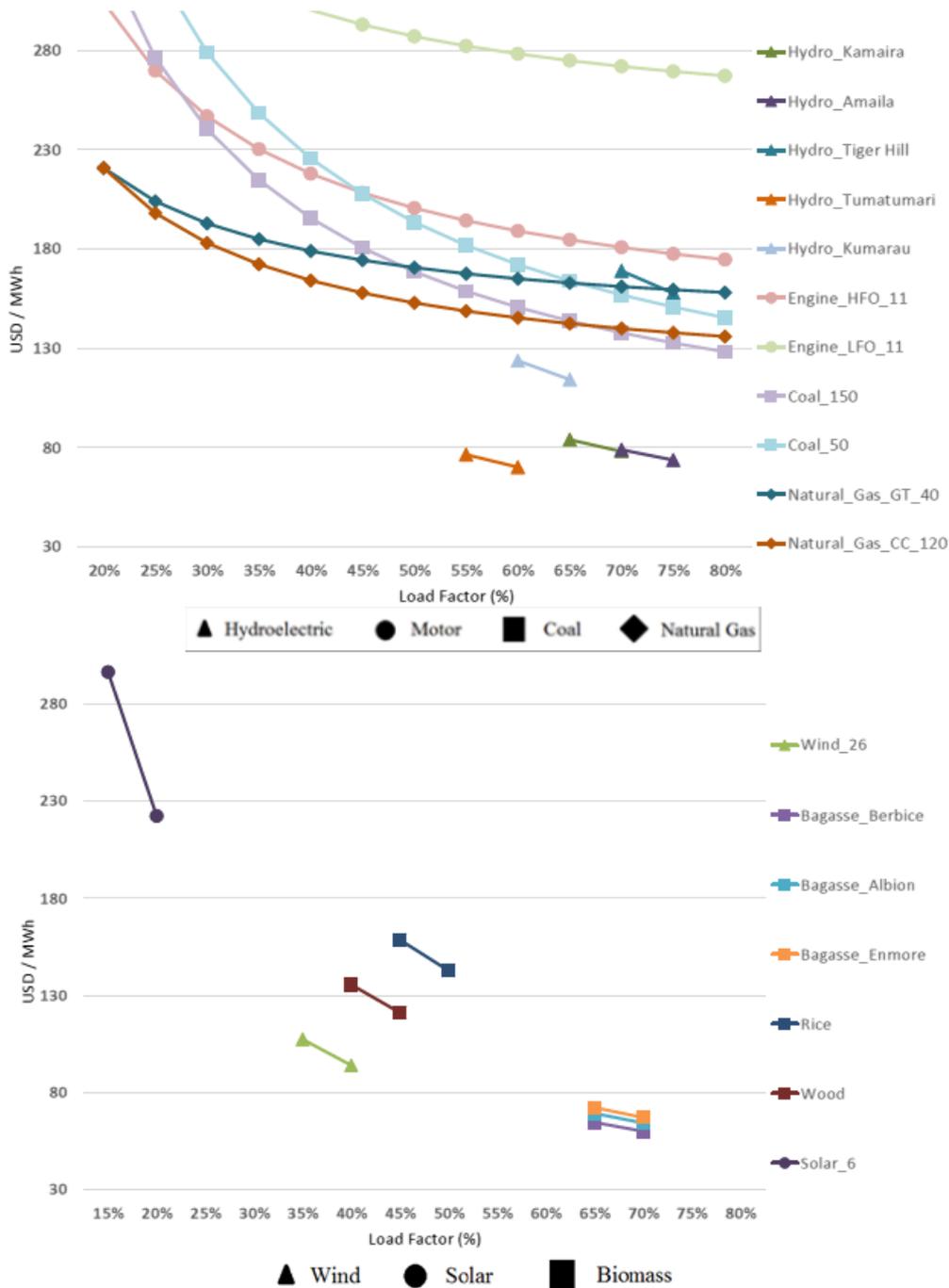


Figure 1 Cost of alternatives - Source: Brugman SAS

When optimizing the system, the study concludes that the lowest average system cost of energy is 10.4 USc/kWh with AFHP being commissioned in 2021³⁶. An alternative with Kamaria Hydropower plant instead of AFHP is the second lowest alternative at an average cost of 10.6 USc/kWh, marginally higher than with Amaila Falls. These unit costs are based on expansions with wind, solar, LFO reciprocating engines and bagasse thermal plants in addition to hydropower. The recommendation in that study is as follows:

³⁶ Considering the present situation we anticipate earliest realistic date for commissioning to be mid 2023

- **2016-2020:** 26 MW of a wind plant in 2017, 2x11.4 MW-LFO in reciprocating engines in 2018, 6 MW solar photovoltaic in 2018-2019 and a plant of 0.7 MW using wood residues.
- **2021-2025:** Installation of a 150-180 MW hydroelectric power plant in 2021 and 9.8 MW in bagasse power plants in 2025
- **2026-2030:** 5.7 MW in bagasse power plants in 2027
- **After 2030:** Conversion of all reciprocating engines to natural gas in 2031 and installation of 3x11.4 MW reciprocating engines using natural gas.

As pointed out elsewhere in this report the above recommendation cannot fulfil Guyana's commitment to developing an emission free or emission neutral energy generation system.

8.4.3 Conclusion

From a financial and economic point of view, development of Amaila Falls seems to be the optimal solution for meeting the electricity demand in Guyana. The project should be financially restructured in order to make it more attractive for GOG and potential investors. Since the perceived risks of investing in Guyana are high, mainly due to political and regulatory reasons, one possible way for Norway to support the project would be to issue guarantees to the project for the repayment of the loan. This would reduce the financing costs substantially, and the risks for the equity sponsor of the project. We recommend that possible guarantee support mechanisms are evaluated as part of the further work on the project.

The financing challenge as a result of the perceived risk of investing in Guyana would be the same for all projects of a similar size, and substituting AFHP with another hydropower project of a similar size would not make any difference. With the suggested financial restructuring of the project, the annual payments from GPL may be reduced by 20% compared to the original proposal, and the annual costs for GPL would significantly lower than operating the existing thermal plants in Guyana.

9 GENERATION SYSTEM EXPANSION

9.1 Least Cost Expansion

The recommendable approach for planning hydropower development is to perform a least cost development study of promising sites at a comparable level of investigation and study. The outcome of the study will be a ranking of the project options by criteria including specific generation cost, production profile and reliability, environmental/ social sustainability and perception of construction risks. From the ranking the order of implementation will be decided.

A number of studies have been carried out through the years in Guyana of various potential sites for hydropower development, although a broad least cost development study comparing and ranking the alternatives at similar cost and study bases, is yet to be done.

Guyana's Power Generation System Expansion Study (Brugman SAS June 2016), which includes several types of power plant, presents four projects of similar size as candidates for the first major hydropower project. These include Amaila Falls (162 MW), Kamaria (152 MW), Kumarau (149 MW) and Tumatumari (152 MW). Amaila Falls and Kumarau are high head projects with modestly sized reservoirs. Kamaria and Tumatumari are low head projects causing inundation of larger areas.

Further investigations and studies are required for the three other alternatives to bring them to a stage of preparation comparable with AFHP. The Brugman report underlines the need for updating of the earlier studies (from 30-40 years back) for creating a reliable basis for comparison. Over the last decades development agencies and international development banks have reinforced their standards for environmental and social studies as condition for financial support.

9.2 Reasons for Retaining Amaila Falls

The Brugman SAS' report does not show any of the three other alternatives convincingly more favourable than Amaila Falls.

It presents Kumarau with a specific generation cost about 50% higher than AFHP and a plant factor of 60-65% compared to 70-75% for AFHP.

Tumatumari is shown with a marginally lower levelized generation cost than Amaila Falls. The plant factor for Tumatumari, however, is given as 55-60% against 70-75% for AFHP. Consequently, Tumatumari would need higher back-up capacity than AFHP for covering the power deficit in low flow periods. This makes it less suitable for fulfilling the ambition of emission free power generation by 2025. Tumatumari has a much larger inundated area than AFHP, which would give larger scale environmental impacts and require time consuming environmental studies.

Kamaria is presented with specific generation cost marginally higher than for AFHP and with a plant factor 65-70% compared to 70-75% for AFHP. The studies for Kamaria Falls dating back to the 1970-ties will apparently need thorough upgrading for providing a reliable basis for comparison with AFHP.

To our judgement developing "Owner's Technical Requirements" for any of the three other alternatives will take 1-2 years more than updating the same for Amaila Falls.

Although certain design aspects of AFHP should be reviewed and revised, we regard the soundness of AFHP as evident and in order to follow up the intentions of the LCDS as fast as possible, we recommend the preparations for AFHP to be resumed.

10 THE WAY FORWARD

10.1 General

We support an initiative for updating a least cost development study among projects that have been studied to a pre-feasibility or feasibility stage several years ago. This will, however, take time. If further preparations for AFHP are kept on halt in the meantime, it is our judgement that at least 2 additional years will elapse before the first hydropower project can be ready for operation. In parallel with resuming the preparations for AFHP, a least cost development study among other promising candidates should commence. Based on the outcome the second hydropower project for implementation should be selected.

Under the present circumstances, we would not suggest trying to implement AFHP as an all public sector enterprise, but recommend to maintain the earlier intended private/ public partnership model for realising Guyana's first major hydropower project.

The first hurdle to overcome is obviously to reach political consensus on restoring AFHP as the first major step towards an emission-free/ emission-neutral electricity sector in Guyana. Both recent studies³⁷ on system expansion support the choice of Amaila Falls Hydropower Project as a cornerstone in the development of the generation system. GPL is currently preparing its Development and Expansion Plan for 2016 – 2020 and GOG (Ministry of Public Infrastructure) is preparing a "Green Paper" for Guyana's energy sector. The "Green Paper" is expected by December 2017. The work is supported financially by IDB³⁸.

In order not to lose more time than necessary, a decision should be taken shortly, supported by the opposition, to resume preparations for the implementation of AFHP.

Three possible ways can be imagined for the way forward:

1. Buying out Sithe Global from AFHI and resuming the negotiations with China Rail, which were interrupted after the change of Government in May 2015.
2. Buying out Sithe Global from AFHI, identifying and assigning a new main sponsor in AFHI and resuming negotiations with China Rail as EPC Contractor only.
3. Buying out Sithe Global from AFHI, identifying and assigning a new main sponsor in AFHI, updating EPC tender documents and assigning a new EPC Contractor after a new tendering process.

Alternative 1 may seem the fastest way for reaching start of construction and thereby project commissioning. Nevertheless, by reasons explained elsewhere, we do not recommend to continue along this path.

We doubt that Alternative 2 may attract sufficient interest from potential new sponsors. Restoring China Rail as EPC Contractor would also most probably cause NICFI withdrawing its support to the Project

Alternative 3 means starting at the pre-EPC tender stage. The old EPC tenders are not a good basis for contract negotiations 8 years later. New tendering gives the opportunity to review and update the tender documents, provide the necessary transparency in the process and create confidence among potential investors.

The next sub-sections anticipate Alternative 3 to be followed for the way forward.

The preparations for buying out Sithe Global from AFHI were interrupted when the negotiations with China Rail, as potential new main sponsor, came to a stop in May 2015 after the change of Government. Negotiations for buy-out of Sithe Global should be resumed once GOG makes a decision to restart the preparations for AFHP.

³⁷ (1) "Initial Study on System Expansion of the Generation & Transmission System" July 23rd 2014, and
(2) "Guyana's Power Generation System Expansion Study" June 2016.

³⁸ Source: IDB

10.2 Developer/ Main Sponsor

A major task for revitalising AFHP is identifying and assigning a new developer/major sponsor to take Sithe Global's earlier position.

A new attempt to attract sponsors needs to be made targeting international investors in the global hydropower market. In order to establish broad interest among well experienced and reputed international sponsors, it is most important that the political parties succeed in reaching a lasting agreement on the way forward. This would reduce potential investors' perception of political risk by the project and thereby make engagement in the project more attractive and reduce the mark up on the tariffs for covering such risk.

Thereafter a briefing document should be issued to the investor market describing the role of the project in Guyana's power system, the natural conditions in the project area, explaining the main technical features of the Project and outlining the intended development model.

It is our opinion that a similar constellation as negotiated, but not concluded, with China Rail as main sponsor/majority partner, as well as EPC Contractor, should not be considered again with any new candidate sponsor.

10.3 Transmission Line

Other potential hydropower developments in the same region, including a possible second stage of AFHP, would need connection to a future integrated Guyanese power system. To avoid construction of several parallel lines in the future, increasing the capacity of the AFHP line should be considered.

Redefining the line as part of the backbone of a transmission system expansion plan may open for separate long term loan financing as a public sector project on better terms, possibly partly on grant basis, which could reduce the initial tariff to be paid by GPL. In this way a manageable additional investment at the beginning may give substantial saving later.

As mentioned in sub-section 7.4 the transmission line could as well be included in the EPC Contract to safeguard duly construction completion and commissioning of the line.

Further investigation of this possibility should start in parallel with the preparations for attracting candidates for a new main sponsor/ developer.

10.4 Technical Review

A drawback of having a private commercial investor in the driving seat in the Project Company is that his interests in the Project as Owner/ Investor will cover the 20 years' duration of the BOOT agreement only, while its partner GPL should consider the Project's life span in a 100+ years' perspective as well as for its position as the power off-taker. This difference in positions is not to be avoided in a private/ public partnership BOOT model, but should be kept in mind by the final owner (GPL) to ensure that his long term interests are safeguarded in the definition of "Owner's Technical Requirements".

In parallel with the efforts to identify a new main sponsor, certain technical features of the project should be reviewed. Such review should include required changes in the cross sections of the pressure shaft and pressure tunnel to achieve satisfactory regulation stability of the plant, and the need for a bottom outlet in the dam in the longer perspective of the Project's life.

It should also be considered whether the EPC competition should open for a layout alternative with powerhouse underground.

In order to save time we suggest that this review is performed in parallel with the preparations for attracting candidates for a new main sponsor/ developer.

This will require support by foreign technical expertise, as well as interim financing of the related expenses, until a new main sponsor is in place. We assume that these expenditures can later be part of GOG's (GPL's) equity contribution in AFHI (or in a new SPC substituting AFHI).

The conclusions of the technical review should be incorporated in an updated "Owner's Requirement" document.

10.5 Supplementary Field Investigations

We recommend a program for additional field investigations be carried out before a new round of EPC bids.

Such program should include seismic profiling along the entire dam base and along selected portions of the tunnel alignment. The result should be checked by drilling at critical locations and incorporated in the EPC tender documents. The benefit of this would be reducing the EPC Contractor's need for mark up on his prices for covering geological risk, which may lead to lower bids.

In addition, the program for daily water flow measurements at the project site initiated by Sithe Global should be resumed in order to improve the input for simulating the potential energy production, which may in turn reduce the uncertainties related to the PPA and provide a more reliable basis for preparing back up capacity.

Better basis for assessing future sedimentation and life span of the reservoir should be provided by sediment sampling over at least one whole year cycle of varying seasons.

10.6 Environmental and Social Issues

In parallel with technical project preparations the following environmental and social issues need to be addressed:

- A stand-alone access management plan should be developed and implemented. Considering the advanced stage of the access road construction this should be handled as a matter of urgency.
- Developing the existing draft to a full and final environmental and social management plan.
- Review, update and repeat the consultation program with affected local communities.
- Elaborate on the Environmental Flow Requirement (EFR) for better justification of the proposed minimum environmental flow (MEF)

10.7 Need for a Technical Adviser/ Independent Engineer

To be able to resume preparations for AFHP Guyana will need continued support from IDB (or another development facility that may be able and willing to take on IDB's former role).

In addition there will be a need for an Adviser for technical support to GOG in the interim period for tasks mentioned under sections 10.3 through 10.6 above until AFHI (or another SPC substituting AFHI) is revitalised with a new developer/ main sponsor in place. A Technical Adviser during this time would be required for mainly three reasons: (1) Saving time, as much of the technical and environmental preparations can be initiated and carried out in parallel with the efforts to identify and assign a new developer/ main sponsor; (2) GOG may need support to define its position in questions where there could be conflicting interests between GPL as the power off-taker/ final long term owner & operator of AFHP, and the main sponsor as seller and owner/ operator in a 20 years' BOOT perspective; and (3) GOG may need support for defining a frame for AFHI and a new main sponsor.

If admissible, according to guidelines for payments from NICFI, we may suggest some of the USD 80 million presently deposited at IDB being used for project preparation, including services by a Technical Adviser, until a new developer/ main sponsor is assigned, assuming that this expenditure later will be converted to become a part of GOG's equity contribution in AFHI (or another SPC substituting AFHI).

Later on, after the different agreements are in place, there will be a need for an Independent Engineer as a mediator in potential conflicts between GOG/GPL and the new main sponsor, as partners in the project company and as parties to the PPA. If agreed between the parties, the Technical Adviser to GOG/GPL in the interim period, may take the role as Independent Engineer at the time when the new main sponsor is assigned. The position of an Independent Engineer would be most important during the preparation and construction period, but should be maintained for the duration of the BOOT agreement.

10.8 EPC Tendering

The next round of EPC tendering would have to be managed by the SPC after a new developer/ main sponsor has been assigned.

We believe most of the structure and contents of the earlier EPC tender documents³⁹ can be maintained for a new round of tendering. However, before starting a new round all documents will have to be reviewed by the new developer/ main sponsor and be updated to reflect changed circumstances including the results of the supplemental field investigations performed and technical review done by the Independent Engineer.

In parallel with updating of the tender documents a new round of pre-qualification of EPC candidates should be made. We would recommend 3, or maximum 4, of pre-qualified candidates to be invited for presenting tenders. The reason for limiting the number is to achieve as well prepared and competitive tenders as possible.

As in the first round of EPC tendering, we believe that Chinese companies may be among the most interested in a new round of tendering in spite of the failure of the first EPC tender competition to reach the stage of construction. As explained elsewhere in the report, inviting China Rail in the next round may not be a good idea.

10.9 Time Horizon

If GOG maintains AFHP as the highest priority project in the transition of Guyana's electricity generation to a green regime and decides to restart the project planning within the end of 2016 (following alternative 3 under sub-section 9.1) it is our estimate that the EPC Contractor may be given Notice to Commence by the end of 2019.

We support the estimate in IE's Report that a construction period of 3.5 years is required from Notice to Commence. That means AFHP may be ready for commercial operation by July 2023.

³⁹ Assuming that the earlier EPC tender documents are parts of the buy-out assets from SG

ANNEX 1: MEMO REGULATION STABILITY OF AMAILA FALLS HYDROPOWER PROJECT

MEMO

Prepared by: **XinXin Li**

Date: 08 July 2016, updated 26 August 2016

SUBJECT

Regulation stability of Amaila Falls Hydropower Project

Summary:

As AFHP is supposed to be designed for operation under isolated grid conditions, frequency regulation stability is of vital importance. In this memo, regulation stability analysis of this plant based on the Norwegian practice is presented.

Conclusions

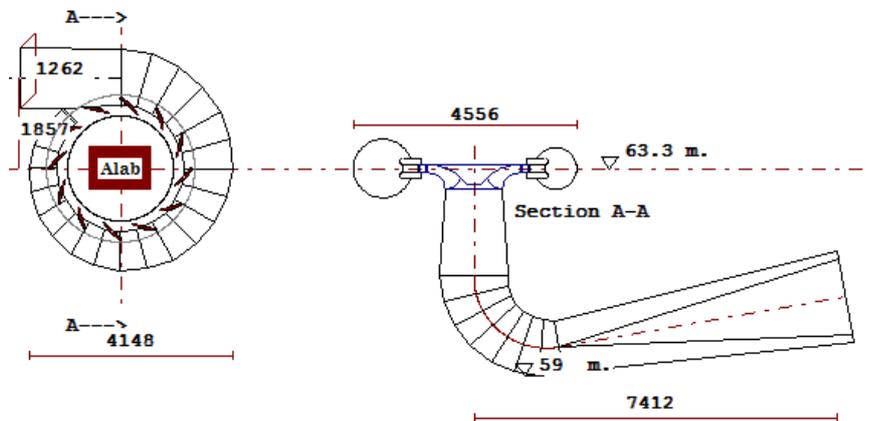
- The waterway system of the current design does not fulfill the basic stability requirements.
- The length of the pressure shaft & pressure tunnel has to be shortened considerably or the cross section of the pressure shaft & pressure tunnel has to be increased considerably. Three alternative options are suggested in this memo to resolve the stability problem. Two options, denoted as Case 3 and Case 4 assume the powerhouse relocated underground further upstream on the waterway. One option, denoted as Case 5, based on powerhouse as previously located at surface at the end of the waterway, requires the pressure shaft & pressure tunnel cross sections increased by 100% and 40% increase of the moment of inertia (GD^2) of the rotating parts of the generating units compared to "natural design" of the units of the actual head, capacity and rate of rotation.

1.1 Basic information

- Generation capacity $4 \times 41.25 = 165\text{MW}$. (Plant discharge $52 \text{ m}^3/\text{s}$)
- Turbine type: Francis.
- Rated head 345 m
- MWH drawings: C-11, C-12, C-13, C14, C20

1.2 Turbine speed selection

The optimal turbine speed is found to be 600 rpm (or alternatively 720 rpm) according to Norconsult's turbine dimensioning and parameter optimization program,



Main turbine properties ...	
Turbine type	Francis
Output, Mw	41.25
Head, m	345
Speed, rpm	600
Best point flow, m^3/s	11.02
Speed number	0.2793
D22, mm	1185.7
u22, m/s	37.25
Efficiency at best point	94.7
Efficiency tolerance at best point, %+-	0.5
NPSH, m	11.8

Figure 2 Turbine dimensioning

1.3 Unit acceleration time constant

The unit acceleration time constant T_a (also referred to as machine time constant) is an importance parameter in the stability analysis. The natural (normal) T_a value for a generator of 41.25MW (appx. 50 MVA) is about 5 seconds according to the statistics of Norwegian hydropower plants, see the figure below, where each point represents an actual generating unit in the Norwegian system:

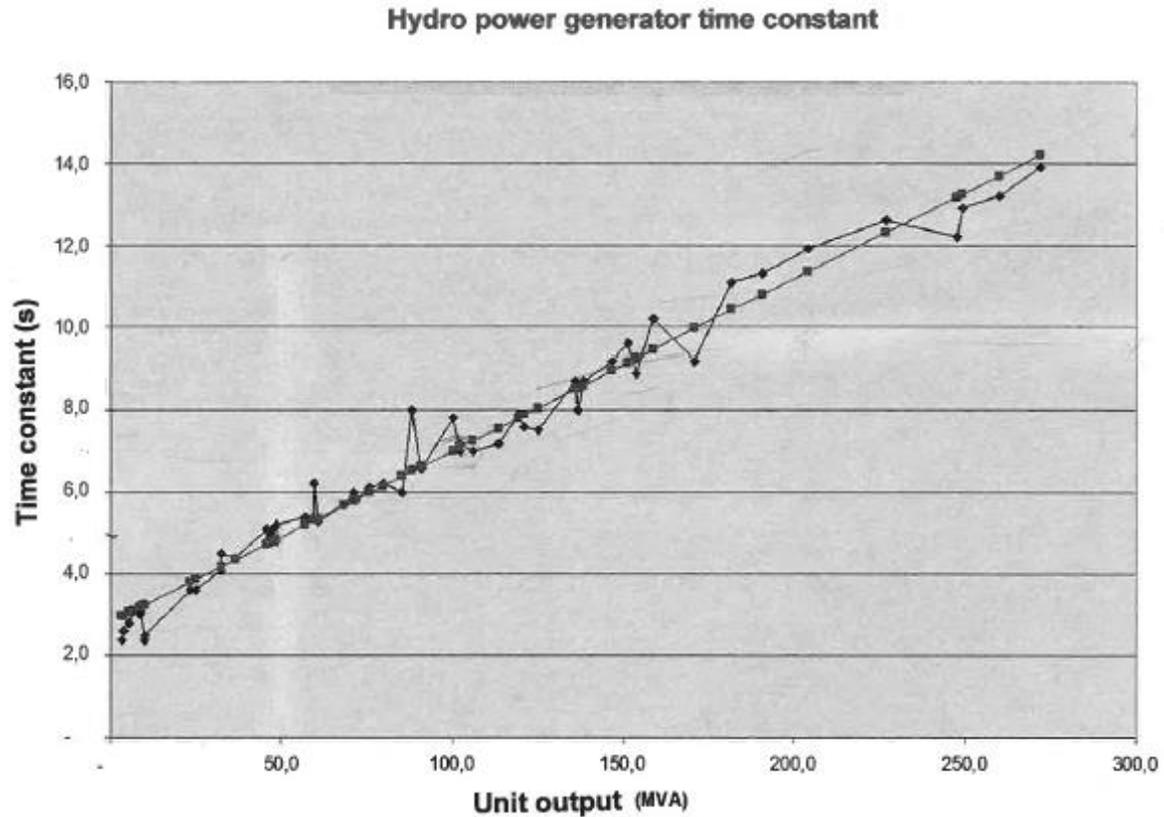


Figure 3 Hydro power generator time constant

It is possible to obtain higher T_a value (than the natural value) by increasing the unit rotation mass (GD^2). An GD^2 increase of 15-20% is normally considered not very difficult. However if an increase of 50% or more is required, a flywheel may have to be used. Flywheel for vertical unit is expensive and practically very difficult.

$T_a = 5$ seconds (estimated natural value)

- Corresponding to unit $GD^2 = 209 \text{ tm}^2$ if 600 rpm is selected as unit rotation speed.
- Corresponding to unit $GD^2 = 145 \text{ tm}^2$ if 720 rpm is selected as unit rotation speed.

1.4 Stability acceptance criteria

The acceptance criteria used in this analysis are based on the requirements outlined by the Norwegian power grid authority (STATNETT). With open loop frequency response characteristics presented in Bode or Nyquist diagrams:

- Phase margin between 25° and 35° at zero gain
- Gain margin between 3.0 dB and 5.0 dB at - 180° phase angle.

If the open loop criteria above are obtained with the following governor parameters (serial structure foreseen), the stability according to the STATNETT is classified as follows:

Table 5 Stability

Regulation stability	Good	Acceptable (Average)	Poor
Integral time Td (s)	$T_d < 8$	$8 \leq T_d < 12$	$T_d \geq 12$
Transient Gain Kp (-)	$K_p \geq 3$	$2 \leq K_p < 3$	$K_p < 2$

Transient speed drop $bt = 1/K_p$.

Based on the above classification, acceptable / average stability is required by STATNETT for all new power plants with total capacity greater than 10MVA. We therefore select the following stability margins as acceptable criteria:

- Open-loop phase margin: > 25°
- Open-loop gain margin: > 3 dB

(With regulator parameters $K_p \geq 2.0$ and $T_a \leq 12s$)

1.5 Stability analysis

1.5.1 Case 1, the current pressure shaft design with a natural unit GD^2

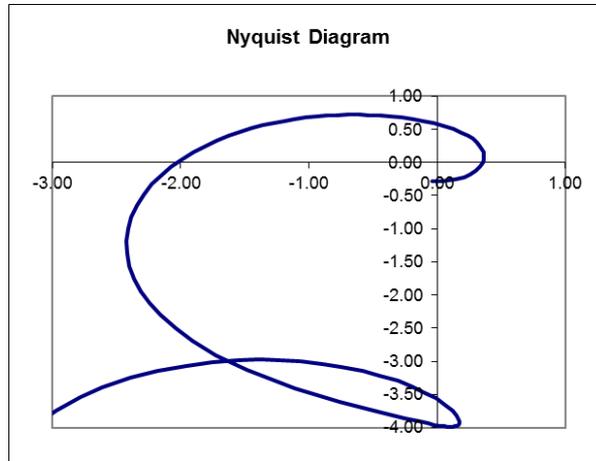


Figure 4 The current design with a natural unit GD^2 , negative stability margins

The Nyquist diagram of the system shows negative stability margins, an indication of instability.

1.5.2 Case 2, the current pressure shaft design with a 40% increased unit GD^2

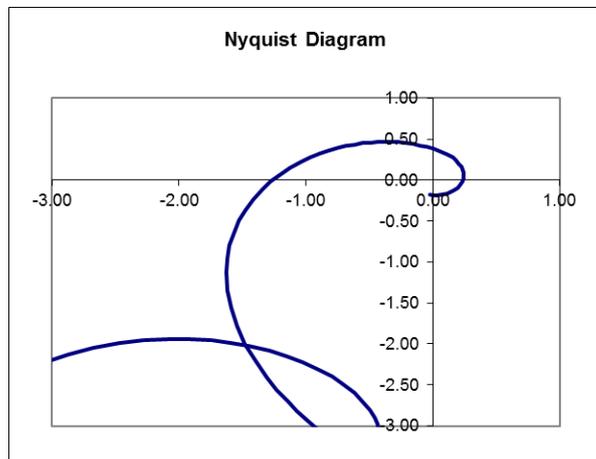


Figure 5 The current design with 40% increased unit GD^2 , negative stability margins

The system is still unstable after an increase of 40% in unit GD^2 .

1.5.3 Case 3, with shortened pressure shaft length

Shortening the length of the penstock can reduce the Tw value of it and thus improve the stability. The total penstock length of the current design is about 1540m. This calculation shows what happens if the total length shortens to 700 m.

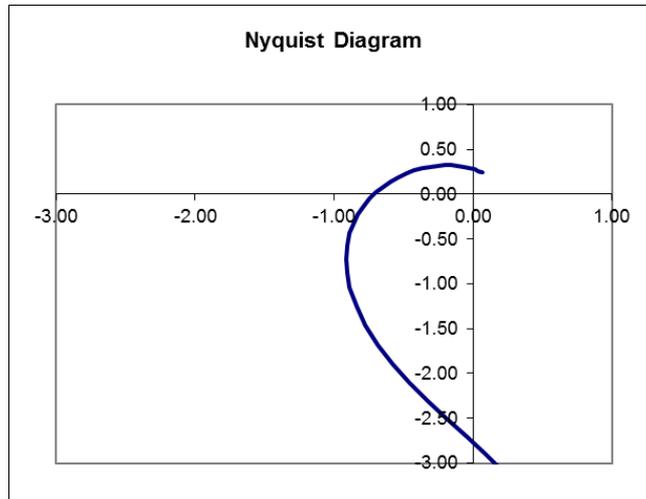


Figure 6 Natural unit GD2, penstock shortens from about 1540m to 700 m

The stability margins: Gain margin: 3.0 dB (The stability requirement fulfilled)
 Phase margin: 25.0 degrees (The stability requirement fulfilled)

1.5.4 Case 4, pressure shaft shortens to 830m + unit GD² increase by 20%

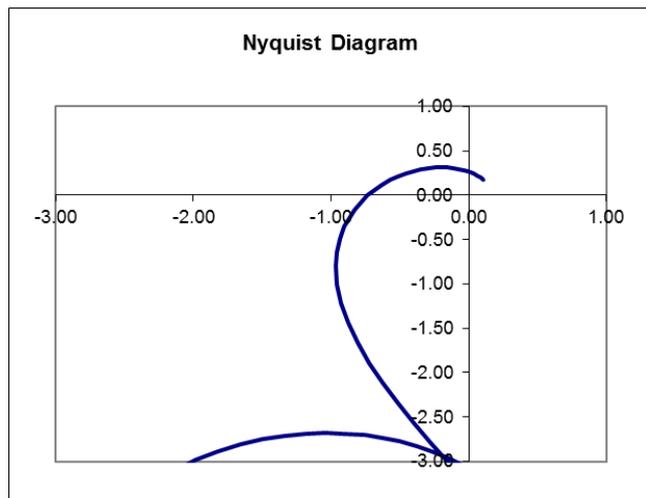


Figure 7 Unit GD2 increase by 20%, penstock shortens from about 1540m to 830 m

The stability margins: Gain margin: 3.0 dB (The stability requirement fulfilled)

Phase margin: 26.0 degrees (The stability requirement fulfilled)

1.5.5 Case 5, Unit GD² increase by 30% + penstock cross-section area increase by 100%

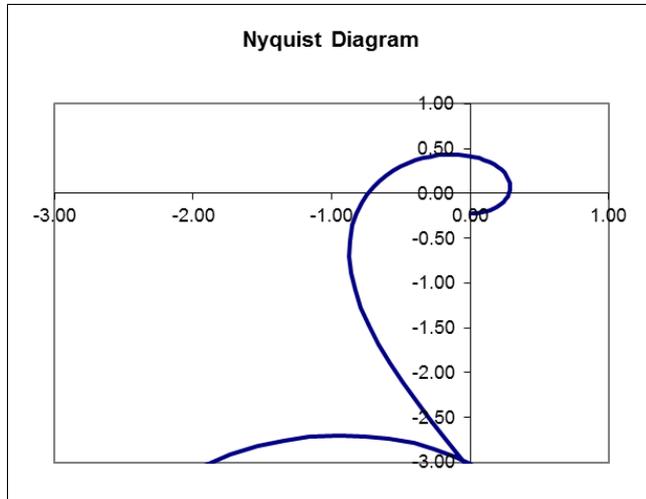


Figure 8 Unit GD2 increase by 30%, penstock cross-section doubles

The stability margins: Gain margin: 3.0 dB (The stability requirement fulfilled)

Phase margin: 27.0 degrees (The stability requirement fulfilled)