Rehabilitation of Péligre Hydro Plant in Haiti

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Introduction

Haiti capital, Port-au-Prince, metropolitan high voltage grid holds an installed power capacity of about 240 MW comprised of one hydropower plant (Péligre HPP) and four thermal power plants, yet only part of this capacity is available on a firm basis. With a nominal production capacity of 54 MW Péligre HPP, located in the Artibonite watershed of Haiti Central Plateau, is the second largest power plant of the metropolitan grid and thus a key element of the Port-au-Prince energy supply.

Construction of Péligre dam was completed in 1956; from 1969 to 1971 the complex was upgraded with a powerhouse and three hydro generating units forming Péligre HPP. Ever since their installation in the 1970s the generating units had only faced basic maintenance provided by the OEM and after 40 years of operation, Péligre HPP electromechanical equipment had reached its useful life. Average annual production had decreased below 150 GWh of the potential 320 GWh, mainly due to equipment failures compounded to reduced water volumes in the reservoir. In this context and with the aim of helping to restore Haiti's capacity to generate electrical power with renewable energy sources, the Inter-American Development Bank (IDB) approved in November 2008 a first grant to cover the cost a first generating unit and common electrical equipment to be rehabilitated (Project Stage 1). Additional resources from OPEC Fund for International Development (OFID) and the German Kreditanstalt für Wiederaufbau (KfW), as well as supplementary financing from the IDB, were subsequently secured to fund the cost for rehabilitation of the second and third units (Project Stages 2 and 3). Rehabilitation works over the three Project stages were expected to take 33 months starting end of 2010, but the 2010 earthquake that struck Haiti delayed by one and a half years the bidding evaluation process from the contemplated timeline.

Mid 2010 Fichtner GmbH & Co. KG (Fichtner) was appointed Owner's engineer by Electricité d'Haïti (EDH), the state-owned utility and operator of Péligre HPP, for the supervision and surveillance of all rehabilitation works. The scope of Fichtner's consulting services started with bid appraisal and award of contract for works in the end of the tender process. Contract signature with the Contractor finally took place in early 2012. However, a fundamental change of strategy had to be adopted during contract negotiations as the conditions of Haiti's electrical sector, aggravated by the situation in Port-au-Prince after the 2010 earthquake, precluded shutting down Péligre HPP completely for several months to execute the works as originally envisioned. This change of strategy entailed considerable complications for the rehabilitation of Péligre HPP—notably of submerged hydraulic steel structures—and led to complete overthrow of the projected implementation schedule. Reservoir drainage was cancelled, thus diving works were required to carry out assessment and refurbishment of hydraulic steel structures. As a consequence the first generating unit was isolated and handed over to the Contractor for rehabilitation only in March 2014, thus marking the actual start of Project Stage 1.

On a technical scale the rehabilitation of Péligre HPP aims for an extension of the plant's life span by refurbishment of the generating units and all auxiliary systems. Given the fact that hydro-electrical equipment has not seen substantial refurbishment in the last 40 years this does not only involve replacement of main components, but also implmentation of a modern digital control system and automated plant operation. The first unit was re-commissioned in July 2016 after 29 months of rehabilitation works. Since April 2016 the second and third unit are out of operation and currently under rehabilitation works by the Contractor. Their re-commissioning is planned for February and April 2018 respectively.

This paper is meant to be an account, at an intermediate yet advanced stage in the project implementation, of the project highlights since inception as well as of the challenges faced throughout its execution.

1. Background

1.1 Overview of Haiti's Electricity Sector

Haiti's electricity sector is served primarily by the State-owned Electricité d'Haïti (EDH) across its four segments of generation, transmission, distribution and sales. EDH is an autonomous government agency overseen by the Ministry of Public Works, Transport and Communications. It was established in 1971 together with the commissioning of the first unit of Péligre HPP, which became the major source of electricity supply of the metropolitan area of Port-au-Prince until the 1980s. Then EDH began to rely on diesel generation plants to meet demand growth. In the 2000s, EDH started to contract energy supply from Independent Power Producers (IPP).

Nowadays, the electrical system of Port-au-Prince metropolitan area includes one hydropower plant (Péligre), four thermal power plants (Carrefour, Varreux, Pétion, and Michel Arthur Volel) and ten substations (including the newly commissioned Tabarre) interconnected by a 69 kV transmission system and a 56 km long 115 kV transmission line between Péligre HPP and Tabarre substation. Péligre (54 MW), Carrefour (49.5 MW) and Varreux (70 MW) power plants are owned by EDH, although Varreux is operated and maintained by the private company, SOGENER; Pétion power plant (34 MW), built within the framework of the Petro-Caribe Haiti-Venezuela-Cuba tripartite agreement, is owned by Venezuela (51%) and Haiti, and is operated and maintained by the firm ESD Engineering; Michel Arthur Volel power plant (30 MW) is owned and operated by the IPP E-POWER.

Both before and after the earthquake of January 2010, electricity service in the metropolitan area of Port-au-Prince has been critical due to several factors: (i) low availability of EDH generation capacity related to inadequate maintenance and lack of spare parts, (ii) low reliability of transmission and distribution grids, and (iii) lack of needed investment. Electricity shortage in Port-au-Prince is chronic: Electricity service covers in average 11 to 15 hours per day in the Port-au-Prince metropolitan area since the electrical distribution system has been fully restored after the 2010 earthquake.

1.2 Péligre Scheme Main Features

Péligre HPP is located in the Artibonite watershed of Haiti Central Plateau in the Centre department. A 70 m high and 263 m wide gravity dam impounds Lake Péligre, formed along the Artibonite River valley, see Fig. 1 below. The dam was erected from 1953 to 1956 by the US Army Corps of Engineers with aim to control flooding and provide water for irrigation of the agriculture lands of the Central Plateau as well as a possibility for hydroelectric power generation. Spillway gates and a powerhouse with three generating units were installed between 1969 and 1975. The plant first produced electricity in 1971.

Fig. 1: Péligre dam before powerhouse construction (left) and before rehabilitation in 2012 (right)

The powerhouse comprises three turbine-generator units fabricated by the Italian manufacturer Ansaldo. The three vertical Francis turbines had an initial peak power of 18 MW totalling an installed power of 54 MW for Péligre HPP.

Fig. 2: Location of Péligre HPP in Haiti (source: Google Maps)

1.3 Initial Generation Data and State prior to Rehabilitation

After completion in the 1970s Péligre HPP contributed to Haiti's energy supply with an annual production of 320 GWh, stemming from an average power of 47 MW during the rainy period (May to November) and 22 MW during the dry period (December to April).

Until 2008, just before rehabilitation, annual production had dropped below 150 GWh with an average of 30 MW in the rainy season and 10 MW in the dry season. The decline in electricity production represents likewise the reduction of storage capacity of Lake Péligre. Extensive silting due to widespread deforestation in the upper Artibonite region had reduced the storage capacity from the initial volume of 600 Mm^3 in 1956 down to 254 Mm^3 in 2016—a reservoir half-life of only 50 years [1] (live storage has been reduced from 470 to 218 Mm^3 in the same period). This considerably high loss of storage volume of 6 Mm^3/year, equivalent to an annual storage loss of 1% of the initial volume, gradually transforms Péligre HPP from the present storage scheme to a run-of-river scheme. However, the 2008 sedimentation study concluded that during the following 20 years sedimentation was not anticipated to reach the power intakes and adversely affect hydropower production; this conclusion is one of the drivers leading to Péligre HPP rehabilitation programme.

Besides the loss of storage capacity decreased production certainly results as well from lack of long-term maintenance and the high level of degradation of the plant's electro-mechanical equipment. In this context, and as part of its strategy to support Haiti's electricity sector, the Inter-American Development Bank (IDB) financed technical studies conducted by an international consultant to set out a detailed rehabilitation plan and prepare tender documents on the basis of the conclusions of the 2008 sedimentation study. In November 2008, the IDB approved a first grant to cover the cost a first generating unit and common electrical equipment to be rehabilitated (Project Stage 1) with the aim of helping to restore Haiti's capacity to generate electrical power with renewable energy sources.

Indeed, in light of IDB's limited financing available for Haiti at that time, the Péligre HPP rehabilitation programme had been designed to be financed in three separate stages that would mirror rehabilitation of each of the three generating units in order to gain access to additional co-financing from other potential donors.

1.4 Scope of Rehabilitation Works

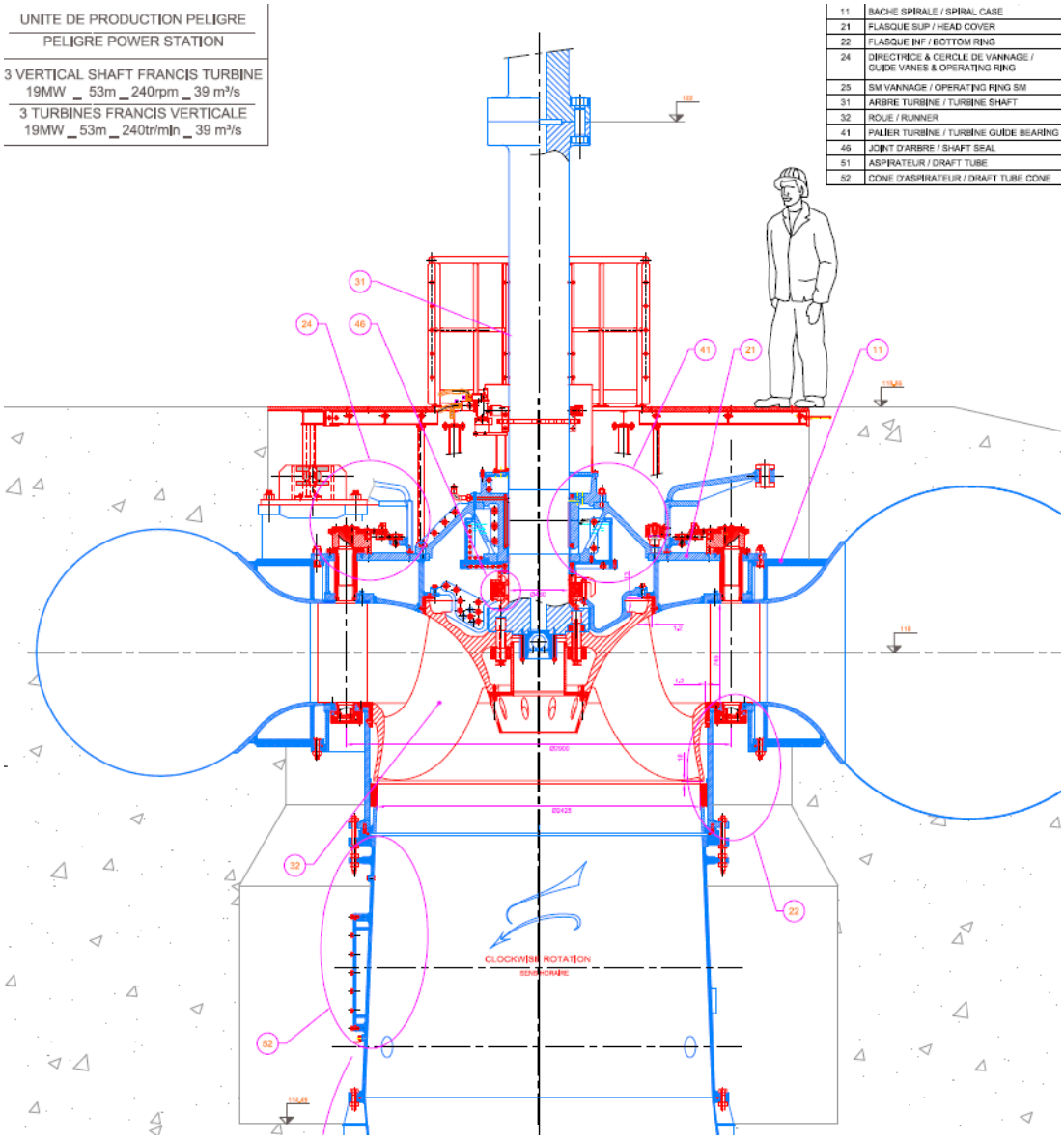

Fig. 4: Turbine cross-section, scope of mechanical rehabilitation (replacements marked red) [courtesy of GE Renewable Energy]

According to the tender Technical Specifications, the following scope of works for electro-mechanical equipments, auxiliary systems and common parts of the plant was envisaged:

- Rehabilitation of the three turbine generator units and main inlet valves (butterfly valves), rotor poles, spiral casing and draft tube steel lining, and full replacement of generator stator, generator thrust bearing, turbine runner, wicket gates, excitation and speed governor systems;
- Replacement of the high voltage switchyard equipment;
- Replacement of the medium voltage switchboards;
- Inspection of two main power transformers and replacement of their electrical auxiliaries;
- Replacement of the complete low voltage AC and DC distribution systems, including auxiliary transformers;
- Full replacement of control and protection systems and implementation of a SCADA system;
- Replacement of mechanical auxiliary systems (cooling water, drainage/dewatering, HVAC, fire protection);

- Refurbishment of powerhouse overhead travelling crane and draft tube gantry crane;
- Rehabilitation of the three power intake gates and three spillway radial gates;
- Rehabilitation of draft tube stop-logs.

The original scope of works included also rehabilitation of bottom outlet valves and construction of a new administration building but these works were subsequently descoped.

2. Procurement Process

Two separate bid processes have been undertaken by EDH under IDB's first grant: (i) the bid for rehabilitation works supervision which was won by Fichtner—contract award in June 2010—and (ii) the bid for rehabilitation works for which the Request for Proposal (RFP) was issued in December 2009.

2.1 Tender Specifications and Initial Timeline

The initial timeline envisaged in the bid for rehabilitation works considered realisation Project period of 33 months distinguished by the stages of

- *Design, conception and fabrication for 16 months*: execute urgent repair works, carry out profound situational analyses in order to assess the condition of scoped equipment, develop conception and prepare detailed design by the Contractor;
- *Reservoir drainage for 7 months*: during a period of 5 months full standstill of Pélgre HPP to allow for rehabilitation of submerged hydraulic steel structures (i.e. inlet gates with trash racks and bottom outlets), certain tasks of refurbishment of civil structures, in large part installation of electrical cabinets and cabling works, as well as excavation of sediments upstream of intakes; and
- *Rehabilitation of electro-mechanical components for 22 months*, including commissioning tests.

The rehabilitation of the three turbine-generator units was planned to be executed within 12 months time for each unit, commissioning included, with a shift of commencement of works of 4 and 6 months respectively between units G2-G3 and G3-G1. This schedule was marked by a considerable concurrence of works during the period of full standstill. During five months, rehabilitation works on (i) hydraulic steel structures, (ii) turbine-generator units G2 and G3, (iii) electrical cabinet erection and cabling works, and (iv) refurbishment of civil structures were meant to take place in parallel—three of which within the powerhouse. The relatively short period of 33 months for all rehabilitation works was thus based on extensive parallel execution, but first and foremost on reservoir drainage and full standstill of Péligre HPP. Both turned out to be rather ambitious and could not be maintained during realisation.

2.2 Change of Strategy during the Procurement Process

EDH has published the RFP in December 2009 with an initial submittal deadline in March 2010. In June that year Fichtner was appointed Owner's engineer for the supervision and surveillance of rehabilitation works. The Consultant's first task was to organise tendering and assist EDH in answering clarification requests from bidders as well as evaluating submitted bids in the end. As an indirect consequence of the January 2010 earthquake, the procurement process was significantly delayed; a site visit of Péligre HPP with following clarifying session for five interested bidders could only be organised in August 2010 and thereafter offers from three companies were eventually received until bid opening in December 2010. Following IDB's approval of the bid evaluation report contract negotiations could finally commence in May 2011 and were concluded in a final clarification session in November 2011. Award of contract took place in February 2012.

During this period—from RFP to award of contract—a fundamental change of strategy had taken place in the rehabilitation project. After the devastating earthquake in January 2010 with a magnitude of 7.0 M_W and the epicentre just 30 km west of Port-au-Prince the country was in a state of emergency. In the capital and other cities in the region the earthquake had caused major damage, 100,000 to 160,000 people had lost their lives and around 280,000 residences and commercial buildings had collapsed or suffered severe damage. An estimated three million people were affected by the earthquake—virtually all inhabitants of the capital's metropolitan area. The vast destruction of infrastructure brought public life to a halt and entailed grave health problems afterwards. Haiti's already fragile economy collapsed and the country appealed for humanitarian aid. Due to the collapse of the power supply in the metropolitan area it was no longer possible to shut down all units of Péligre HPP during rehabilitation as it would be carried out simultaneously with reconstruction of Port-au-Prince.

However, to maintain at least one unit of Péligre HPP operational at all times implicated that reservoir drainage cannot take place—which in turn imposes a change of strategy in terms of rehabilitation of inlet gates and bottom outlets. Furthermore continuous exploitation entailed fundamental modification of all rehabilitation stages on site; starting with sealing of inlets and isolation of generating units, refurbishment of submerged hydraulic steel structures, rescheduling of parallel work lots, and eventually organising a rehabilitation in a running power plant. From the beginning of negotiations with the preferred bidder is was thus clear that (i) foreseen schedule would be obsolete prior to award of contract and (ii) support of divers will be required several times in the course of the rehabilitation.

In view of the disastrous situation in Haiti at that time IDB and EDH recoiled from putting the project on a hold and decided to continue on the basis of already received bids. During contract negotiations, however, it was clearly stipulated that, in contrast to the Terms of Reference, Péligre HPP could not be shut down completely and the Contractor was engaged to prepare a planning and create a quotation for required sub-aquatic works. With aim to facilitate all required planning changes in a most effective way it was likewise decided to assign added sub-aquatic works to the same contractor with the agreement that these works and all consequences in terms of financing and implementation schedule would be settled subsequently according to the mechanism of variations and adjustments foreseen in the contract. On a financial level, the estimated rehabilitation budget proved to be insufficient; all of the received bids—not even accounting for necessary changes in the aftermath of the earthquake—would overspend the foreseen budget. Applications for additional funding were filed to OFID and KfW; the latter entered the project as second lender in February 2011 and provided a first augmentation in November 2013. Supplementary financing by IDB was granted in March 2012 and finally in February 2013 OFID, as third lender, entered the project.

2.3 Contract Addendum 1 and Options

During contract negotiations the Contractor had suggested a number of options and provided quotations. The following options have been incorporated into the contract by means of a first addendum:

- Full replacement of generator stator with a new stator for three groups;
- Full replacement of generator bearing with combined guide and thrust bearing for three groups;
- Full replacement of excitation system with a new system for three groups;
- Delivery of two blind flanges and refurbishment of the existing flange; and
- Delivery of self-lubricating bearings for the three main inlet valves.

In addition to inclusion of above mentioned options, a first price escalation was already necessary due to elapsed time between foreseen and actual mobilisation of the Contractor. This was settled in Addendum 1 in November 2013.

3. Péligre HPP Rehabilitation Programme Execution

Commencement of rehabilitation works on site was preceded by a 20 months period for preparation and realisation of diving works to assess pre-rehabilitation conditions and attain the isolation of the first unit. This unit was then refurbished in a period of 29 months as of March 2014. It was re-commissioned end of July 2016 and is in operation since August 2016. A first inspection in June 2017—after 7,340 hours of operation and towards the end of the guarantee period—showed no signs of cavitation damage on the new runner.

Units G2 and G1 were handed over to the Contractor for rehabilitation in January and June 2016 and are currently being refurbished. Re-commissioning is expected in February and April 2018.

3.1 From Initial Site Visit to Isolation of the First Unit

A first situational analysis on site was carried out by the Contractor in July 2012 with the aim to (i) acquire necessary input to launch engineering works, (ii) assess functionality of intake gates and main inlet valves, and (iii) discuss with Employer and Engineer prerequisites introduced by the change of strategy; from this it was intended to obtain the chronology of works. However, from this mission and a second mission in November 2012 it became apparent that the units cannot be isolated by shutting intake gates and main inlet valves since neither gates nor butterfly valves could be closed watertight. In fact it crystallised that diving works are already required at the very beginning in order to isolate the units and facilitate dismantling afterwards. It was therefore decided to perform at first an inspection in order to assess the condition of submerged intake structures as well as obtain a bathymetric survey of the intake region by means of divers and underwater vessel video recordings. The final programme for this inspection was adopted in January 2013 and the inspection itself was carried out in March 2013.

Not surprisingly the inspection showed advanced sedimentation in the intake region (of all three intakes) and floating debris in front of the trash racks and in the interspace between trash rack and inlet gate. To allow for unit isolation cleaning of the trash rack-gate-interspace and the trash racks themselves was required, see Fig. 3.

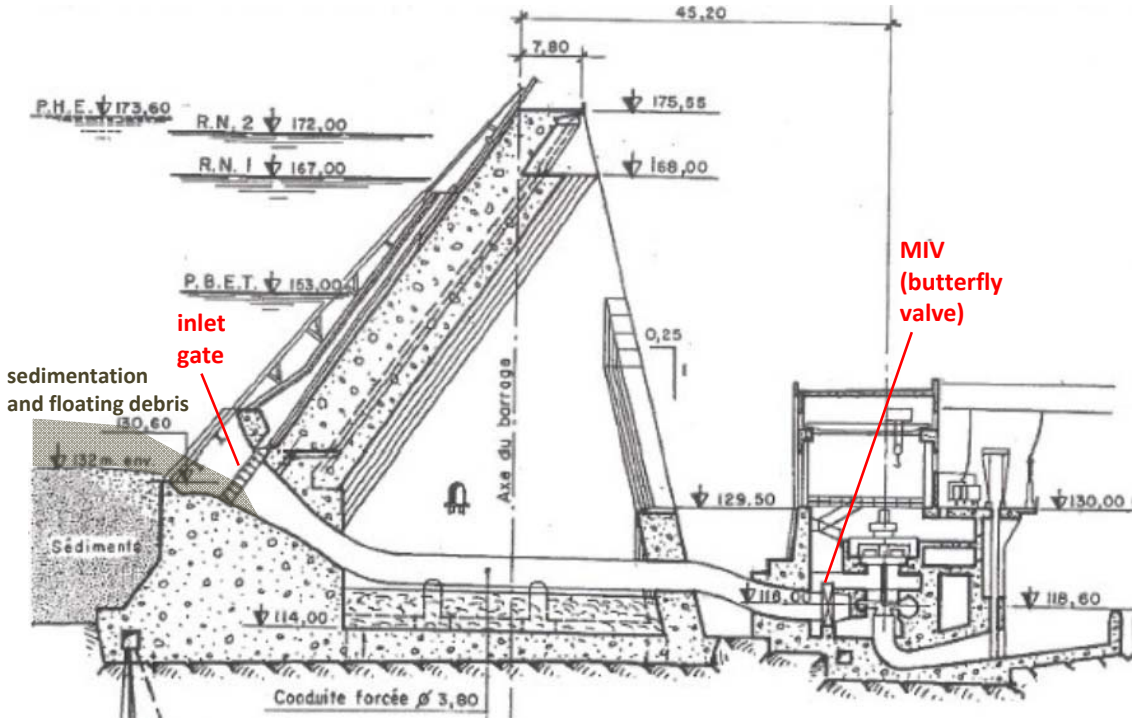

Fig. 3: Barrage cross-section, inlet gate and MIV

Based on these inspection results the Contractor established in May and June 2013 a work schedule for cleaning and isolation works. It was decided to focus on isolation of one unit at first and only carry out minimal cleaning on the other intakes in order reduce head losses of respective generation units. Isolation of group G3 finally started in January 2014—after a five week delay due to custom clearance issues of the diving equipment—and was concluded in March 2014. The first unit was handed over to the Contractor for rehabilitation on March 11, 2014.

3.2 Rehabilitation of the First Unit (Project Stage 1)

Rehabilitation of unit G3 started after isolation in March 2014, dismantling and non-destructive testing (NDT) had been carried out during 15 months. Reassembly of refurbished equipment started in June 2015 and was completed end of June one year later. Commissioning and transfer back to the Employer took place until end of July 2016, totalling to a rehabilitation outage of 29 months. This extension compared with the Terms of Reference—22 months for rehabilitation of all three units has been envisaged—can be explained on the one hand by the change of strategy which did not any longer facilitate extensive parallel execution of rehabilitation lots. On the other hand the unit's condition required a considerable amount of additional repair.

Supplementary work is reflected by a multitude of change orders that became necessary during the first rehabilitation stage of unit G3 and auxiliary systems, among them:

- 15 change orders concerning electro-mechanical equipment of unit G3 itself;
- 19 change orders concerning auxiliary systems and common parts of the plant; and
- 4 change orders concerning spillway gates.

These modifications resulted in an increase of the contract amount that was partially compensated by a reduction of scope for refurbishment of civil structures and bottom outlets.

From an organisational point of view rehabilitation works in the powerhouse were quite a challenge; for safety reasons the Contractor refused to enter the powerhouse when the old units are in operation. Therefore it had been agreed

between Employer and Contractor to shutdown units G2 and G1 during working hours. These units could only be operated at night and from Saturday afternoon to Monday morning. Given the fact that Péligre HPP was until 2016 the only plant capable of restoring the Haitian grid after a major blackout this practice led to several lockouts and interruption of works due to the need to re-establish the grid with unit G2 or G1. On the other hand, since only one unit had been taken care of at this time, there were no limitations with respect to powerhouse crane usage and storage space on the erection bay.

For the sub-aquatic works the following approach was pursued:

- *Upstream isolation*—closing and tightening of inlet gate in order to drain the penstock;
- *Downstream isolation*—placing and tightening of preliminary gate at the draft tube outlet in order to drain the draft tube and facilitate refurbishment of downstream gate embedded parts;
- *Condition assessment*—execution of diving and video inspections in order to acquire information on trash rack blockage and sedimentation upstream of intakes as well as determine state of embedded gate parts.

As a result of inspections the scope of cleaning and/or required repair of embedded parts shall be defined and realised together with diving works for isolation or re-watering of units.

In financial terms this first rehabilitation stage represents about 60% of the contract amount. This clearly shows that the first stage contains not only electro-mechanical equipment of one unit, but also a vast part of auxiliary and control systems as well as common parts of the plant which are indispensable for re-commissioning of the unit. Furthermore all engineering costs had been assigned to the initial rehabilitation stage as well. The Contractor had started conceptual and engineering works end of 2012 and finished all tasks until December 2015. By the beginning of reassembly of unit G3 in June 2015 the Contractor had realised 90% or 52 out of 58 factory acceptance tests, 24 of them with assistance of Fichtner. The huge delay of mobilisation had little impact on engineering and fabrication and only led to a reduction of overlap of engineering with dismantling and installation lots.

Unit G3 was re-commissioned end of July and at Employer's disposal as of August 2016. It was then in 24/7 operation—according to water availability—until shutdown for a first inspection end of June 2017. By this time the unit had been operated for 7,340 hours (in 332 days) and produced 116,623 MWh of electric energy; i.e. a capacity factor[1] of 81.3%. Average output was 14.6 MW with a utilisation factor[2] of 92.1%; this, however, results from a significant number of unit trips due to mechanical or electrical triggering. Apart from several minor issues that have occurred in the guarantee period—summarised in a punch list to the Contractor—unit G3 operation has been satisfactory. Cavitation inspection did not show significant signs of pitting or other damages on the new runner. Visible marks were clearly below the admissible maximum pitting depth of 1.4 mm as well as the admissible total erosion volume of 29 cm^3; it can thus be stated that the new runner fully adheres to the cavitation guarantees given by the Contractor. The guarantee period for unit G3 installations will end in September 2016.

3.3 Contract Amendments and Rehabilitation of the Remaining Units (Project Stages 2 and 3)

After the decision had been taken to start the project as planned, despite of the short-term change of strategy, it was clear that the contractual framework had to be adapted in parallel to project realisation. In fact, at the moment of signature, the Contractor and involved parties were fully aware they are signing an already obsolete set of agreements. However, this was a deliberate choice with aim to quickly improve the situation in Haiti rather than put the project on a hold and prepare new Terms of Reference. As a consequence this imposed a huge responsibility to Employer and Engineer in terms of project supervision.

Normally a contract for procurement of goods, works, and non-consulting services stipulates rights and obligations between Employer and Contractor in a well balanced manner. Contract templates are available for construction projects, so called greenfield projects, and rehabilitation projects with respective focus and risk allocation approach; well known and frequently used are FIDIC[3] contract models and procurement guidelines. Péligre rehabilitation,

[1] The *capacity factor* is the ratio of actual electrical energy output over a certain period of time to the maximum possible output in this period.

[2] The *utilisation factor* is the ratio of actual time during which the unit is in operation to the maximum possible time it could have been in operation.

[3] International Federation of Consulting Engineers ("Fédération Internationale des Ingénieurs Conseils"), Geneva, Switzerland; www.fidic.org

however, is based on a different contract template which is not particularly suited to rehabilitation projects. The situation was further aggravated with signature of Addendum 1 in which completion dates for all units were nullified. In return the Contractor was engaged to provide a planning update and incorporate necessary diving works; new completion dates were then to stipulate in a separate addendum after the parties agreed on a new project schedule. This approach unbalanced the contractual equilibrium to the Contractor's benefit—again supposedly targeting to move forward with a view to swift realisation by carrying out re-planning and initial engineering works in parallel. As a result a binding project schedule for Stages 2 and 3 became effective only at the end of 2016, after re-commissioning of the first unit and return of experience of its rehabilitation.

Rehabilitation of the first unit—including a major part of auxiliary systems and common plant parts—took 29 months from isolation to re-commissioning, whereas unit G2 and G1 rehabilitation would be largely in parallel and planned to be finished after 24 and 21 months respectively. Remaining sub-aquatic works have been contracted in an addendum in July 2015 and comprise the following phases:

- Phase 2—sealing of unit G2 for rehabilitation, removal of inlet gate of unit G3 for refurbishment;
- Phase 3—sealing of unit G1 for rehabilitation, removal of inlet gate of unit G2 for refurbishment;
- Phase 4—removal of inlet gate of unit G1 for refurbishment.

Phase 2 was completed in early 2016 with isolation of unit G2 and re-watering of unit G3 in a second diving mission during ten weeks. On January 22, 2016 unit G2 was handed over to the Contractor for rehabilitation and from this time only unit G1 remained in operation. Isolation and hand-over of this last unit was envisaged after re-commissioning of the first refurbished unit in April to ensure continuous generation. However, after withdrawal and inspection of intake gate of unit G3 it appeared that substantial repair and additional material was required. Works had to be suspended due to extensive delivery time and completion of group G3 was postponed to July 2016. As a consequence this would not allow for uninterrupted operation or imply to postpone isolation of the last unit and thus accept a delay for project completion. The Employer chose to isolate unit G1 according to schedule in April and thereby shut down the plant during a period of four months. Respective diving works started in April and finally led to isolation of unit G1 in June; it was handed over to the Contractor for rehabilitation on June 29, 2016.

All these modifications were settled in several addendums in order to bring the project back into a sound contractual framework; a focus being on re-introduction of completion dates for Project Stages 2 and 3 in order to revert to clear deadlines. With Addendum 5 completion of unit G3 was settled in March 2016, completion of units G2 and G1 followed in Addendum 6 in November that year. In doing so contractual equilibrium was re-established and a binding time schedule for remaining rehabilitation came into effect; completion of units G2 and G1 is scheduled for end of December 2017 and end of February 2018 respectively, re-commissioning is envisaged mid of February and mid of April 2018. At the time of this account, re-installation of both units has been started and is advancing well. No significant change orders for additional repairs are expected and project completion is still envisaged to adhere to stipulated dates.

4. Key Figures and Conclusions

Before rehabilitation, in 2010, overall power of Péligre HPP totalled to 28 MW in peak operation and 20 MW for units G2 and G1 during refurbishment of the first unit. The latter, however, only during 14 hours per day and 41 hours on weekends representing at most 2 GWh of generation per week. Unit G3 offered a peak power of 18 MW after rehabilitation in 24/7 operation which alone surpasses former G2 and G1 generation with a possible maximum of 3 GWh per week.

As mentioned previously, the refurbished unit has generated 116 GWh of electricity in 11 months (i.e. in average 2.6 GWh/week) with an average power of 14.6 MW—and a peak performance of more than 18 MW. As a consequence it can be noted that the main project objective will be met: to re-establish or increase initial unit nominal power of 16.5 MW. Unit G3 has generated 36.6 MWh in the period from January to April 2017 whereas pre-rehabilitation production in the same period was 45.9 MWh in 2012—with all three units available. From this it can be expected to reach or exceed pre-rehabilitation production of 150 GWh per year. The estimate of an annual generation rise of 90 GWh that has been made prior to rehabilitation seems realistic. Initial annual production of 320 GWh can, however, no longer be attained due to the considerable volume reduction of Péligre reservoir.

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The Authors

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Lesly Racine has a Bachelor Degree in electrical engineering and a Master Degree in mechanical engineering. He has been working for Electricité d’Haïti (EDH) since 1985 in various positions, inter alia as Deputy Director for hydro-electrical production and Director of power production. Since 2008 he is project manager of the Péligre rehabilitation project as representative of the plant operator. In addition he lectures “Turbo Engines” at the University of Haiti, Port-au-Prince since 2004.