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Renovation Project for the Eastern Water Supply Galleries of the Hongrin

Complex Logistics and Open-Book Contract for Fair Cost Control

Forces Motrices Hongrin-Léman SA (FMHL), represented by Alpiq SA, launched a call for tenders in 2010 for the renovation of the eastern water supply galleries of the Hongrin hydroelectric infrastructure. Following issues encountered during a first renovation phase (2011–2013), initiated under a contract that was never completed, FMHL and the Hongrin Gallery Consortium (CGH) decided to proceed with an open-book contract. This type of agreement reflects a commitment to transparency and to sharing some of the inherent risks of the construction project.

1. The Project

1.1. General Overview

Forces Motrices Hongrin-Léman SA, owned by Romande Energie SA, Alpiq Suisse SA, Groupe E SA, and the Lausanne Industrial Services (SIL), has been operating the Hongrin reservoir (Figure 1) since 1971 through the Veytaux I power plant, and since 2017 through the Veytaux II power plant. The total catchment area covers 90.8 km^2, of which 45.4 km^2 pertains to the eastern water intake network. Alpiq is acting as the project owner's representative. Following regular monitoring of the installations, part of the eastern water supply galleries was deemed to be in critical condition, requiring renovation to maintain water transfer functionality. The engineering firm Gruner Stucky SA was commissioned to develop the rehabilitation project. After the failure of an initial contract, the Hongrin Gallery Consortium (CGH), which includes JPF SA and InfraTunnel SA, was commissioned in 2015 to carry out the renovation work.

Credit: Geologos SA

***1** Aerial view of the Hongrin reservoir*

Projekt zur Sanierung der östlichen Zulaufstollen am Hongrin

Komplexe Logistik und Open-Book-Vertrag zur fairen Kostenkontrolle

Die Forces Motrices Hongrin-Léman SA (FMHL) hatte 2010 – vertreten durch die Alpiq SA – eine Ausschreibung zur Sanierung der östlichen Zulaufstollen der Wasserkraftinfrastruktur Hongrin eingeleitet. Nach Problemen in einer ersten Sanierungsphase (2011–2013), die im Rahmen eines nie fertig gestellten Vertrags eingeleitet worden war, beschlossen die FMHL und das Hongrin Gallery Consortium (CGH), mit einem Open-Book-Vertrag fortzufahren. Solch eine Vereinbarung spiegelt eine Verpflichtung zur Transparenz und zum gemeinsamen Tragen eines Teils des dem Bauvorhaben innewohnenden Risikos wider.

Projet de rénovation pour les galeries d'adduction EST de l'Hongrin

Logistiques complexes et contrat à livre ouvert pour un contrôle équitable des coûts

Les Forces Motrices Hongrin-Léman SA (FMHL), représentées par Alpiq SA, ont lancé un appel d'offres en 2010 pour la rénovation des galeries d'adduction EST de l'infrastructure hydroélectrique de l'Hongrin. Suivant les problèmes rencontrés lors de la première phase de rénovation (2011–2013), initiée dans le cadre d'un contrat qui n'a jamais abouti, FMHL et le Consortium CGH – Galerie Hongrin ont décidé de poursuivre les travaux avec un contrat à livre ouvert. Ce type d'accord reflète un engagement envers la transparence et le partage d'une partie des risques inhérents au projet de construction.

Progetto di risanamento delle gallerie di rifornimento idrico est dell'Hongrin

Logistica complessa e contratto open book per un controllo equo dei costi

Nel 2010 Forces Motrices Hongrin-Léman SA (FMHL), rappresentata da Alpiq SA, ha pubblicato un bando di gara per il risanamento delle gallerie di rifornimento idrico est dell'infrastruttura idroelettrica dell'Hongrin. In seguito alle problematiche riscontrate durante la prima fase di risanamento (2011–2013), avviata nel quadro di un contratto che non è stato mai completato, FMHL e il Consorzio Galleria Hongrin (CGH) hanno deciso di procedere con un contratto open book. Questo tipo di accordo riflette un impegno a favore della trasparenza e della condivisione dei rischi intrinseci del progetto di costruzione.

1.2. Timeline

Discussions and planning regarding the renovation method began in 2015 in order to define the final construction schedule. The civil work, with a total duration of 21 months, was divided into three construction seasons to allow the network of galleries to remain operational during periods of high water inflow. Additionally, the start of the project was postponed by one year due to COVID-related health restrictions:

- June 2021 to March 2022 (9 months)
- June 2022 to December 2022 (6 months)
- June 2023 to December 2023 (6 months)

1.3. Project Figures

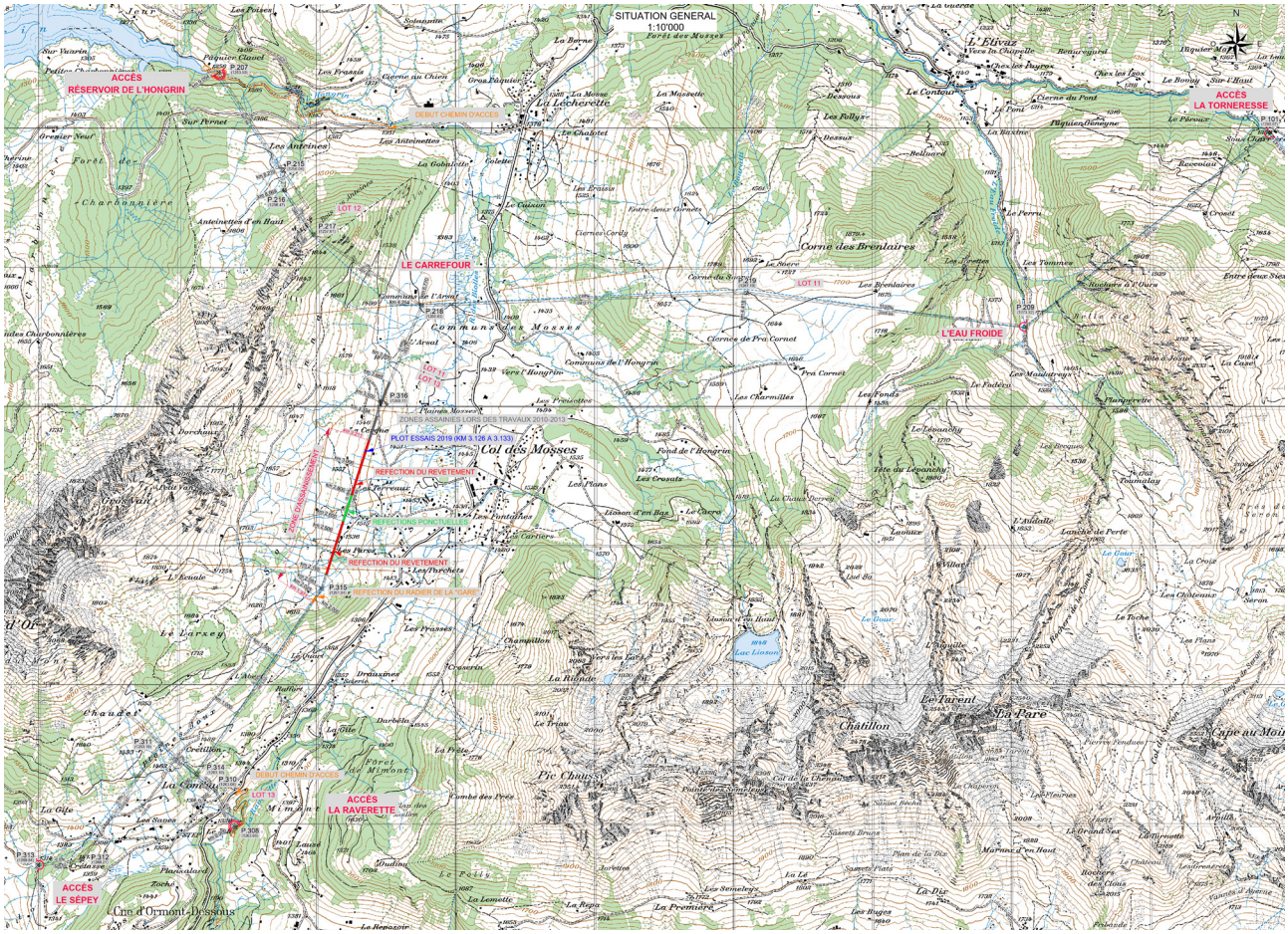
The renovation project concerns a section of the Raverette branch between TM 1,971 and 3,211. This branch is part of a network of water supply galleries spanning over 10 km, made up of three branches: Raverette, Torneresse, and Hongrin. The first two, supplied by several water intakes, join into a common gallery located 3 km from the outlet at the eastern end of the Hongrin reservoir (Figure 2).

The tunnel section, divided into four parts, includes:

- 816 meters with complete renovation (411 m + 405 m)
- 200 meters of localized renovations (tunnel vault and sidewalls)
- 54 meters of invert renovations

Here are some key figures regarding the quantities of materials used during the construction work:

- 7,949 tons of excavated material
- 4,718 tons of shotcrete
- 680 linear meters of concrete segments installed
- 3,272 saw cuts

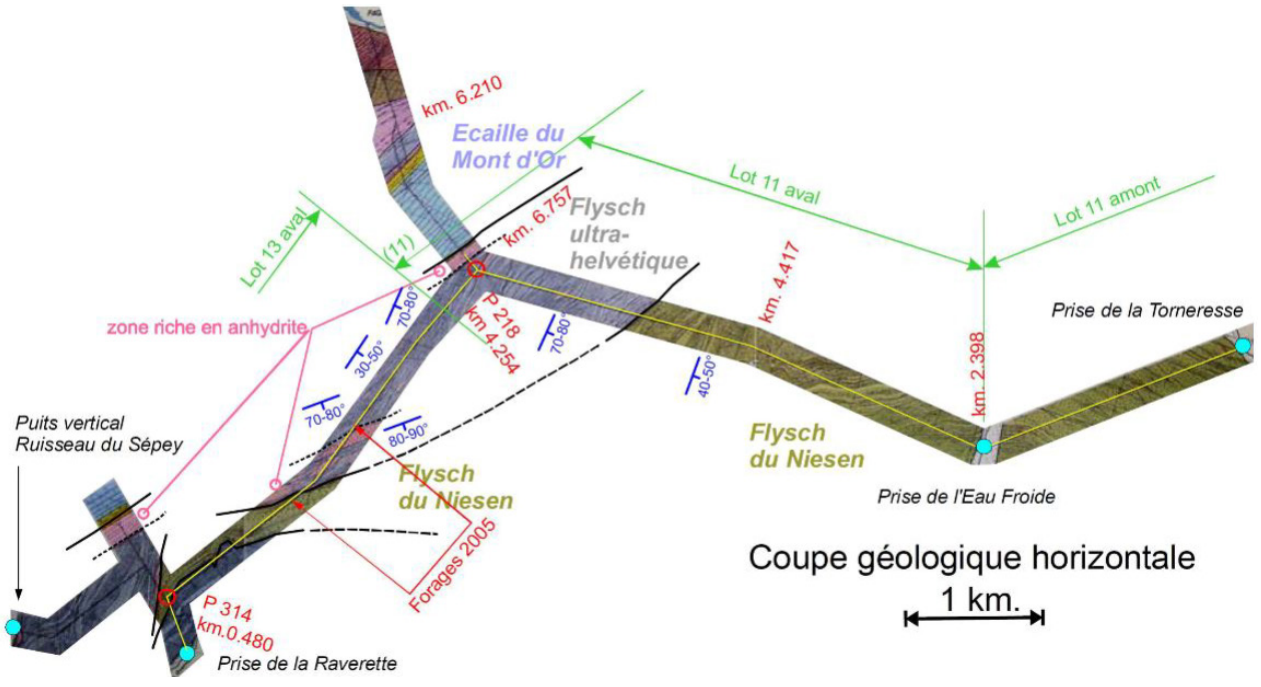


Credit: Gruner-Stucky

***2** Location of the East Long Gallery*

1.4. Geological Context

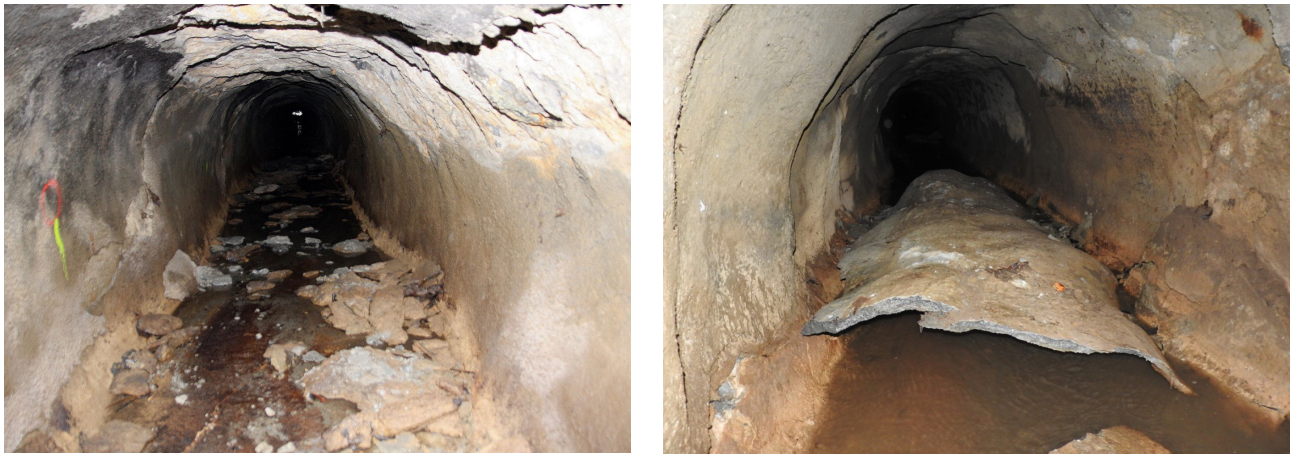
The galleries were excavated through two main geological formations: the Ultrahelvetic Flysch and the Niesen Flysch (Figure 3).



Credit: Gruner-Stucky

***3** Geological situation of the galleries*

The most significant damage is located in the Ultrahelvetic Flysch, which is mainly composed of alternating lenses of clayey schist and anhydrite. When in contact with water, anhydrite can deteriorate and transform into gypsum, accompanied by a volume increase. Moreover, both anhydrite and gypsum release sulfates, which have degraded the concrete lining (Figure 4).



Credit: Gruner-Stucky

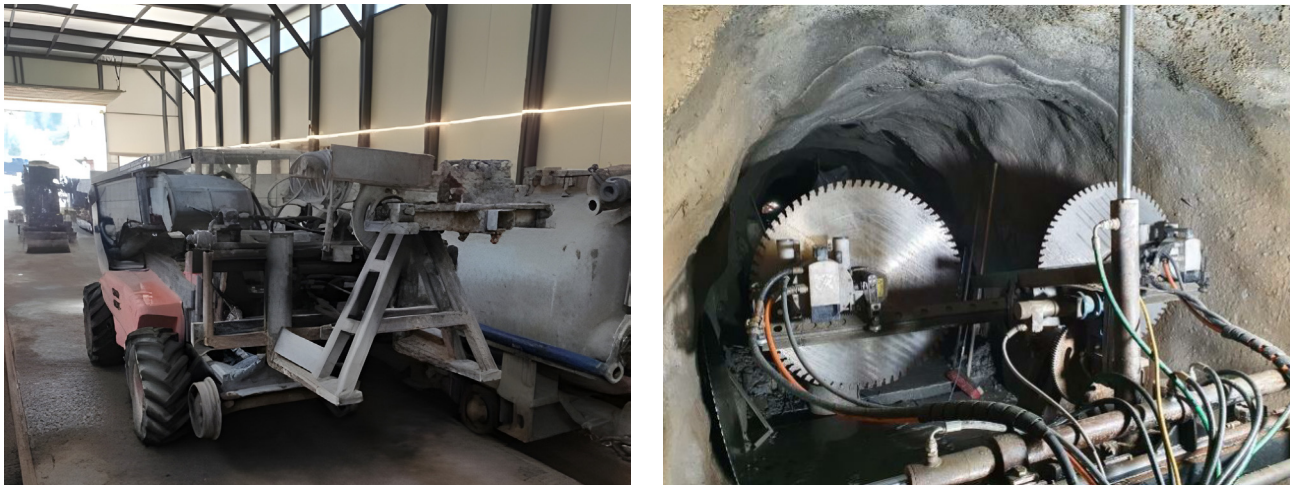
***4** Condition of galleries before restoration*

1.5. Preliminary Tests and Excavation Method

In 2019, prior to the contract signing, and in order to better manage the risks for both the client and the contractor, a shotcrete test was carried out using a mold with a similar profile. This was done to validate the selection and type of shotcrete to be used. A trial section was also conducted over a stretch of about ten meters to refine the methodology for weakening the rock, and for excavating both the concrete and the in-situ rock. In 2020, due to the COVID-19 pandemic and the associated health constraints, the start of construction was postponed by one year by mutual agreement between the parties. Based on these experiences, the excavation cycle was defined as follows:

- Weakening of the section to be excavated using saw cuts;
- Demolition of the vault and sidewalls;
- Application of safety shotcrete;
- Excavation of the invert;
- Installation of concrete segments;
- Application of the final lining shotcrete.

The tunnel section cutting was performed by Mauroux, a subcontractor of the consortium. To meet the technical requirements of the site, a machine was specially adapted for the task. A Manitou loader was equipped with a rotating axis onto which two motors were mounted to drive the cutting discs (Figure 5).



Credit: CGH

***5** Sawing equipment*

The dual-disc cutting method made it possible to perform full-section cuts with a 180° axis rotation. This allowed for high productivity without hindering excavation progress, which was dependent on ventilation flow.

The excavation machines were selected according to the dimensions of the galleries:

- Brook 170 for demolition;
- A Bobcat S70 for mucking;
- A Menzi Muck 12SA excavator for cleaning.

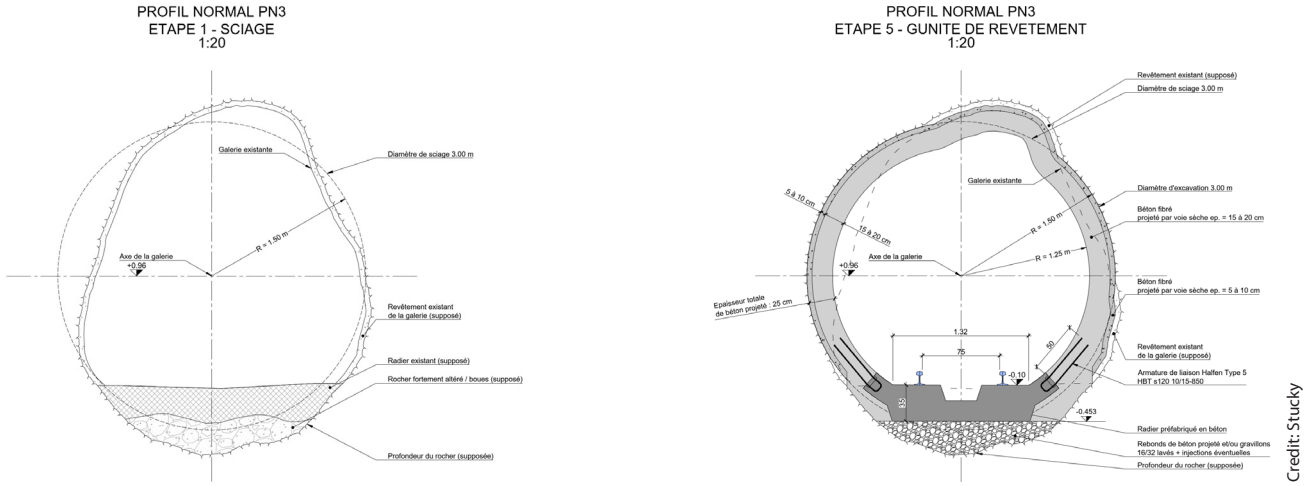
All of these machines were heavily used and subjected to extreme conditions. Therefore, at the end of each construction season, a general overhaul was carried out to minimize mechanical failures. In the context of this site, each breakdown posed a significant logistical challenge.

1.6. Technical Specificities of the Project

This project stands out due to several major constraints:

- The worksite is located in the heart of a tunnel network more than 10 km long. The operations were carried out at distances ranging from 3,084 m to 4,507 m from the access portal.
- The tunnel cross-section is very narrow, with a minimum diameter of just 2.30 meters (Figure 6).
- The seasonal nature of the work, with harsh winter conditions.
- The constant presence of water inside the galleries.

These constraints required the implementation of logistics specially adapted to the unique configuration of the site.



Credit: Stucky

***6** Typical gallery profile*

1.6.1. Construction Site Facilities

The external construction site installations (Figure 7) had to be designed to withstand the seasonal nature of the work and harsh winter conditions.

- The roof of the site facilities (base camp) was specially reinforced to support heavy snow loads.
- A 40-meter-long by 12-meter-wide hall was installed to keep heavy inventory protected from the weather during the off-season.

Credit: Geologos SA

***7** Aerial view of outdoor site installations*

To keep the work areas dry, a water management system is implemented at the beginning of each season. Cofferdams, installed at the ends of the galleries downstream from the decommissioned water intakes, retain as much water as possible, leaving only minor inflows to be managed at the actual work zones. The water volumes collected behind the cofferdams also served as a water supply source for the construction site.

The electrical supply for the site was another major challenge. Romande Energie SA was commissioned to carry out the electrical installation work. The unique aspect lay in assembling and dismantling the equipment at the start and end of each season, including the installation of a 16 kVA medium-to-low voltage (MV/LV) transformer (Figure 8) and the entire low-voltage line.

Credit: CGH

8 *MV/LV Transformer cab before gallery entrance*

The 3,680 m-long medium-voltage line remained equipped with a gallery during seasonal power cuts. To guarantee the safety of the installation, this line was inspected before the start of each work season.

1.6.2. Worksite logistics

To ensure that the worksite ran smoothly, a logistics inventory was specially designed to ensure that all the various materials could be brought in and out of the tunnel's limited dimensions.

Credit: CGH

9 *Locomotives*

A rail logistics system has been set up to manage transport flows in the gallery. Two site trains pulled by electric locomotives were equipped for the various phases of the advancement cycle (Figure 9). Each locomotive has two interchangeable batteries, enabling it to operate 24 hours a day, 5 days a week.

A train conveying the platforms could be equipped with skips for marinating or with a hold for the segments (Figure 10). This made it possible to evacuate excavation materials and supply the segmental linings. In all, the site had around fifteen multi-purpose platforms.

Credit: CGH

10 *Drive train configurations*

A shotcrete train consisted of a shotcrete robot, a compressor and four horizontal silos (Figure 11). Each shotcrete silo, with a capacity of 2.5 m^3 of material, was equipped with a mixing system to limit settling of the material during rail transport.

Credit: CGH

11 *Loading of the shotcrete train*

Credit: CGH

12 *Installation of invert segments using the monorail*

In the tunnel, equipment specifically adapted to the tunnel's dimensions had to be used for the shoring and installation of the invert segments. The heavy elements were managed by installing a monorail attached to the forward movement. The monorail allowed the handling of shoring buckets and prefabricated invert between the train and the forward movement (Figure 12).

The use of this inventory and the miners involved on the site enabled an average progress rate of 75 cm per shift to be maintained, and the work to be delivered according to the contractual schedule.

Progress	Excavation Vault	av./post	Excavation Invert	av./post	Concrete Lining	av./post	Sawing
Season 1	303 m	0.69 m	263 m	0.60 m	262 m	0.60 m	411 m
Season 2	217 m	0.77 m	198 m	0.70 m	199 m	0.71 m	226.5 m
Season 3	298 m	0.85 m	358 m	1.02 m	355 m	1.01 m	180.5 m

Table 1 *Progress rates by season and by activity.*

At the request of the MO, season 1 was shortened by 3 months due to the geopolitical situation in Europe, the tension linked to the country's energy supply and the risk of a blackout in Switzerland. This stoppage made it possible to capture the natural inflow of meltwater and runoff in advance. During season 2, 200 metres of spot repairs (vault and right foot of the sidewall) were also carried out.

2. Contract

2.1. History

The project was first put out to tender in 2010. This tender procedure led to an initial, unsuccessful contract running from 2011 to 2013. The Owner therefore issued a recall of the projects that had been put out to tender in 2010, which led CGH 2nd in the tender procedure to confirm its interest in taking over the project. After discussions, analyses and definition of the final project variant, the Owner's past experience with this complex project led it to propose remuneration based on an open book system.

2.2. Open book

The principle of the open book is complete transparency of construction costs. The consortium gives the Owner all its prices, and together they establish a remuneration system for each item of expenditure. This framework enables the contractor to guarantee remuneration of his cost price (direct SMIT costs) as well as indirect costs (via the SEE calculation scheme). In return, the contractor transfers a percentage of the accounts for the risks and benefits as well as for the financial costs associated with remuneration via instalments during the civil works.

2.2.1. Implementing the open book system

In order to avoid unpleasant discussions during the project, it is important to set up a system that includes all the services for the site. This was done in collaboration between the project Owner/Construction management/Contractor. Once all the costs were known to the project Owner, we had to work out how to allocate them fairly. The breakdown of these costs has been divided into 5 sections (A-B-C-D-E). Each section covers one aspect of the worksite:

- A: Initial mobilisation and final demobilisation of worksite facilities (including all services for the mobilisation and demobilisation of the worksite, broken down into lump-sum costs, reimbursable costs and salary costs);
- B: Site operating costs (including capital expenditure and maintenance of site facilities);
- C: Progress costs (including remuneration on an SMIT basis);
- D: Partial demobilisation (including transport and wage costs);
- E: Partial remobilisation (including transport and wage costs).

Examples include:
In Book A:

- Remuneration for electrical installation is paid on presentation of the service provider's invoices, as this is a job that is likely to change over the duration of the site.
- The provision of water treatment facilities, paid for on a lump-sum basis, as this is a fixed item for the entire site.

In Book C:

- Prices for hours worked underground in the tunnel and hours worked outside as per daily statement.
- Materials as per invoices.

- Inventory paid per item at the TFI rate for the inventory used.
- Third parties as per invoices.

Once the various amounts and quantities have been established, the reference amount excluding tax serving as the contractual basis is agreed, in this case CHF 14,920,000.

In the event of unforeseen work, the creation of a new item of expenditure in reimbursable costs, as well as changes to the reference amount if additional work is required according to the various site contingencies, remain entirely possible following discussion and agreement between the parties.

2.2.2. Remuneration

Remuneration according to the open-book method is therefore based on requests for advance payments, which the contractor draws up in advance of the planned services and which enable him to cover his direct and indirect expenses.

Each month, the quantity surveys are drawn up on the basis of the various specifications, enabling us to check that the value of the advance payments corresponds to the costs incurred by the site. In this way, as the site progresses, the amount of the advance payments is adjusted as accurately as possible by the company for the following season. It is also possible, with the agreement of the project Owner, to submit an adjustment payment if the cost projections were initially incorrect.

The aim for the parties is therefore to keep site costs below the contractual reference amount to which they have committed. A system of penalties for exceeding this amount encourages the various parties involved in the project to find common-sense alternatives on the various issues.

Cost increases du to inflation for this project were defined based on the method of calculating the specific work index (MIS) in accordance with the SIA1021/3 appendix. Cost increases were calculated at the end of each season on the basis of turnover. Some items were not taken into account because they belong to the owner (for example, inventory acquired by the owner via reimbursable costs).

2.2.3. Closing the contract

The final invoice for the contract is therefore based on the difference between the advance payments received from the Owner and the actual cost for the work carried out and recorded in the various specifications.

In addition, in order to maximise the desire not to exceed its reference price. The Owner has put in place an adjustment mechanism aimed at distributing the profit between the reference price and the final real price of the construction project.

3. Conclusion

The rehabilitation of the eastern supply galleries of the Hongrin was a technically very interesting project, both in terms of complex preparation of the worksite, and in terms of reflection, identification and anticipation of the conditions that would not allow improvisation, as early as possible in order to best adapt the phases of the works to come.

Credit: Geologos SA

***13** End of the 2023 season before dismantling of outdoor installations*

The open book concept is also a key element in the smooth running of the project. The many hours of work required to transform a CAN tender into an open book have proved their worth over the seasons. This system greatly simplifies financial matters. In fact, the rules are known and shared throughout the execution phase, allowing the technical aspect to take precedence through common-sense solutions, with the aim of producing high-quality and appropriate work.

As a result, at the end of this project, through the technical proposals and the quality of the work carried out, the full operation of the supply galleries is guaranteed for decades to come, in a Swiss energy context that is becoming ever tighter (Figure 13).

The authors would like to thank the project Owner, Forces Motrices Hongrin-Léman SA and Alpiq for allowing this article to be published, the project planner Gruner-Stucky for their collaboration throughout the project, with high-quality technical exchanges, and all those involved, subcontractors and suppliers.

Hydropower has a bright future in Switzerland.

PROJECT KEY DATA

Region
Galerie Est d'Hongrin, Vaud, Suisse

Client
Force Motrice Hongrin-Léman, Alpiq SA

Design, site supervision and overall construction management
Gruner Stucky

Execution
Consortium Galerie Hongrin: JPF Construction SA (pilote), InfraTunnel SA

Key data

Construction period:	June 2021–December 2023
Start of operations:	July 2021
Construction costs:	14'920'000 CHF
Length:	816 ml
Excavated cross section:	Gallery diameter 2.50 m

Special features
Project at the heart of a network of hydraulic tunnels located 4 km from the access portal, with a restricted work schedule requiring complex site logistics, open book accounting, demanding seasonal operating constraints (hydroelectric production and demanding winter weather)