GRANDE DIXENCE
TECHNICAL DOCUMENTATION
# CONTENTS

## THE GRANDE DIXENCE HYDROELECTRIC COMPLEX

- GRANDE DIXENCE 8
- PANORAMIC VIEW OF THE FACILITIES 10
- LONGITUDINAL PROFILE 16

## COLLECTING WORK

- Z’MUTT PUMPING STATION 20
- STAFEL PUMPING STATION 32
- FERPECLE PUMPING STATION 40
- AROLLA PUMPING STATION 50

## STORAGE

- THE GRANDE DIXENCE DAM 60

## PRODUCTION

- FIONNAY POWER PLANT 78
- NENDAZ POWER PLANT 86
- BIEUDRON POWER PLANT 94

## INFORMATION

- GRANDE DIXENCE SA PARTNERS 102
- GRANDE DIXENCE SA SHAREHOLDING PORTFOLIO 103
- CONTACTS 104
THE GRANDE DIXENCE HYDROELECTRIC COMPLEX

Grande Dixence is not only the tallest gravity dam in the world, it is also a masterpiece of technical sophistication and daring devoted entirely to energy. Standing shoulder to shoulder with the highest mountains in Switzerland’s Valais region, the structure is the keystone of a vast hydroelectric complex which includes five pumping stations, over 100 km of headrace tunnels cut into the rock and three power plants. Come and discover the Grande Dixence complex!
Grande Dixence is not only the tallest gravity dam in the world, it is also a living legend.

Level with the highest mountains in the Valais, this structure is a masterpiece in technical skill and audacity channelled into energy. At first sight, you will be astounded by the 285 m of concrete towering above you; once you reach the top of the facility, the stunning view of the Lac des Dix and the valley will take your breath away. The top of the dam forms a gigantic panoramic terrace 15 m wide and nearly 700 m long at an altitude of 2,365 m.

Grande Dixence was built in 1961 to replace the first Dixence dam, which is now at the bottom of the Lac des Dix. It took over 10 years to build this new structure, which is located in a vast hydroelectric complex completed in 1965. The reservoir holds all the water from a catchment area of 420 km² half covered by glaciers. It is these 35 glaciers which, via 75 water intakes, 5 pumping stations (Z’Mutt, Stafel, Ferpècle, Arolla and Cleuson) and 100 km of tunnels, feed the Lac des Dix.

The 400 million m³ of water stored behind the Grande Dixence dam represent 20% of the electricity generated in Switzerland. To make the hydraulic force of the Lac des Dix as profitable as possible, Grande Dixence drives water through its turbines at two levels. The first is at an altitude of 1490 m in the Fionnay plant. The second is level with the Rhône, 1000 m lower at the Nendaz plant. To transform this vast quantity of water into electricity and harness this tranquil force into billions of kWh, the Fionnay and Nendaz power stations work in relay.
With the current installations at Fionnay and Nendaz, the Grande Dixence complex produces a total power output of 800 MW. The Bieudron power plant enables this power output to be increased by 1,200 MW, thereby taking the total power output of the complex to 2,000 MW. Like other hydropower facilities, the main purpose of Cleuson-Dixence is to provide power instantly, on demand. In just 4 minutes, the installation is able to provide the network, with power equivalent to that of a nuclear power station.

The energy produced across all the Grande Dixence-Cleuson-Dixence facilities reaches approximately 2 billion kWh per year, which corresponds to the average annual consumption of 400,000 households.

Grande Dixence SA does not stop at using a renewable energy source. The trustee of an exceptional natural reserve, it has made firm commitments to a policy of sustainable development. This has been undertaken to ensure the use of natural resources is constantly optimised and to limit the actual or possible impact of its installations on the environment. The energy produced by Grande Dixence is certified by several environmental labels.
COLLECTING WORK

The conveyance network collects water from a 420 km² reservoir bordered by the Mischabel, Matterhorn and Mont Gelé mountains, two thirds of which is covered by glaciers. Through 100 kilometres of galleries, including a main tunnel which is 24 kilometres long, at an altitude of 2400 metres in the heart of the mountain, 35 glaciers supply the facility’s raw material via 75 water intakes and 5 pumping stations. Together they supply on average 500 million m³ of water every year.
PUMPING STATION
Z’MUTT

Set at the foot of the Mattertal, the Z’Mutt pumping station (alt. 1972 m) is the most powerful within the Grande Dixence complex. It is fed by water from the Bis and Schali glaciers which rise above the Visp river, and from the Gorner glacier.

Four pumps with a total power of 88 MW are used at Z’Mutt to pump around 140 million m$^3$ of water every season. This water is pumped to a penstock which carries it to the Trift tunnel (altitude of 2400 metres) in the main collector.

The impact of the concrete on the environment has been kept to a minimum. The only major visible element is the arch dam which crosses the gorge. Apart from the service building, all of the facilities (gravel traps, sand traps and pumping station) are underground.

TECHNICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>AFTERBAY RESERVOIR</th>
<th></th>
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<tbody>
<tr>
<td>CONSTRUCTION</td>
<td>1961-1964</td>
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<tr>
<td>HEIGHT</td>
<td>74 m</td>
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<tr>
<td>CREST</td>
<td>144 m</td>
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<td>THICKNESS AT THE CREST</td>
<td>3 m</td>
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<tr>
<td>VOLUME OF CONCRETE</td>
<td>32,000 m$^3$</td>
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</tr>
<tr>
<td>CAPACITY</td>
<td>800,000 m$^3$</td>
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<tr>
<td>TYPE</td>
<td>Arch dam</td>
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<table>
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<tr>
<th>PUMPING STATION</th>
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<tbody>
<tr>
<td>POWER</td>
</tr>
<tr>
<td>2 x 30 MW ; 2 x 14 MW</td>
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<tr>
<td>FLOW RATE</td>
</tr>
<tr>
<td>17.4 m$^3$/s</td>
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<tr>
<td>DISCHARGE HEAD</td>
</tr>
<tr>
<td>365 m / 470 m</td>
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</table>
Z’MUTT PUMPING STATION

PLAN OF LOCATION

1 ARCH DAM
2 Z’MUTT COMPENSATING BASIN, USEFUL CAPACITY APPROX. 800,000 m³
3 FLOWING WATER INTAKE
4 9.3 m Ø CATCHMENT DIVERSION TUNNEL
5 UNDERGROUND PUMPING STATION
6 STEEL-LINED DISCHARGE SHAFT TO UPPER MAIN TUNNEL (TRIFT) Q = 17.4 m³/s
7 BIS SHAFT, STEEL-LINED, 1.35 m Ø
8 BODMEN COMPENSATING CHAMBER, CAPACITY APPROX. 2000 m³
9 SCHALLI-BIS CATCHMENT DIVERSION TUNNEL, Q = 8.0 m³/s
10 COMPENSATING CHAMBER TUNNEL AND OVERFLOW PIPE
11 ADMINISTRATION AND CONTROL BUILDING
12 ZERMATT - Z’MUTT CABLEWAY
13 ACCESS TUNNEL TO PUMPING STATION BRIDGE
14
15 BOTTOM GALLERY
16 ACCESS TUNNEL TO DAM VALVE CHAMBER
17 CABLES SHAFT
18 SUBSTATION
19 130 kV TRANSMISSION LINE
20 ROAD TUNNEL
21 HEADRACE TUNNEL TO THE MUTT POWER PLANT (EZW)
Z’MUTT PUMPING STATION
LONGITUDINAL AND TRANSVERSAL PROFILES
OF Z’MUTT CONDUITS AND SHAFTS

1 TRIFT TUNNEL
2 STEEL-LINED 1.90 m Ø, LINING
   THICKNESS 14 - 11.5 mm
3 STEEL-LINED 1.80 m Ø, LINING
   THICKNESS 24 - 14 mm
4 HIGH-PRESSURE VALVES
   2 x 0.80 m Ø
   2 x 0.70 m Ø
5 Z’MUTT PUMPING STATION
6 LOW-PRESSURE VALVES
   1 x 1.60 m Ø
   2 x 1.20 m Ø
7 2.00 m Ø INLET VALVE
8 STEEL-LINED 2.30 m Ø
   GRADIENT 2 %
9 STEEL-LINED 2.30 m Ø
   GRADIENT 60 %
10 FLOATING WATER INTAKE
11 Z’MUTT COMPENSATING BASIN,
   USEFUL CAPACITY
   APPROX. 800,000 m³
12 SCHALI-BIS TUNNEL
13 BODMEN COMPENSATING CHAMBER
   USEFUL CAPACITY,
   APPROX. 2000 m³
14 LINED OVER 246.54 m, 1.35 m Ø
   LINING THICKNESS 9 mm
   GRADIENT ~ 80 %
15 SCHALI-BIS LOW-PRESSURE VALVES
   1 x 1.00 m Ø
   1 x 1.40 m Ø
Z’MUTT PUMPING STATION
INSTALLATION PLANS

STATION EQUIPMENT AND OPERATION

SUMMER PUMPING

A. 2 SETS EACH CONSISTING OF:
   — 1 pump discharging 5.5 m³/s against 470 m head, and
   — 30 MW motor

B. 2 SETS EACH CONSISTING OF:
   — 1 pump discharging 3.2 m³/s against 365 m head, and
   — 14 MW motor

C. 1 REGULATING SET CONSISTING OF:
   — 1 pump discharging 2 m³/s against 90 - 130 m head, and
   — 3 MW motor
   Total discharge of pumps: 17.4 m³/s

WINTER GENERATION

In winter water from the Trift tunnel is used by sets B, acting as turbines and is returned to the Z’Mutt compensating basin.

10 SINGLE-PHASE TRANSFORMERS
130 / 10 KV
(including 1 standby unit) rated at 30 MVA

1 MACHINES HALL
2 RAILS FOR 30 T OVERHEAD CRANE
3 MAIN ACCESS TUNNEL
4 CABLES TUNNEL
5 DAM ACCESS TUNNEL
6 ESCAPE TUNNEL
7 BOTTOM TUNNEL
8 STORE
9 OIL SUMP
10 SUPPLY PIPE
11 INLET VALVE
12 BIS SHAFT ~ 80 % GRADIENT, Q = 8.4 m³/s
13 ACCESS TO VALVES
14 LOW-PRESSURE VALVES GALLERY
15 HIGH-PRESSURE VALVES GALLERY
16 1.20 m Ø VALVE
17 STANDBY TRANSFORMER
18 AUXILIARIES
19 TRIFT SHAFT
20 TRANSFORMERS I
21 TRANSFORMERS II
22 TRANSFORMERS III-IV

PLAN OF PUMPING STATION, SECTION C-C

LONGITUDINAL SECTION B-B

CROSS-SECTION A-A
Z’MUTT PUMPING STATION

PLAN OF DAM

1 ACCESS TUNNEL
2 VALVES HOUSE
3 OVERFLOWS
4 RESTITUTION SLUICE
5 BOTTOM SLUICE
6 PURGE PIPES FOR BOTTOM SLUICE
7 FLOATING WATER INTAKE
8 DIVERSION TUNNEL
9 2.30 m Ø SUPPLY PIPE TO PUMPING STATION
10 FURI-STAFEL ROAD TUNNEL
11 PENDULUM SUSPENSION CHAMBER
12 0.80 - 0.60 m Ø ACCESS SHAFT
13 0.40 m Ø PENDULUM SHAFT
14 REFERENCE CYLINDER
15 ACCESS TUNNEL TO THE DAM CREST

SECTION THROUGH AXIS OF DAM
Located at the foot of the Matterhorn (alt. 2180 m), the Stafel station pumps 70 million m$^3$ of water every year. It is supplied with water from the Z'Mutt glacier. The station pumps the water up to the collector, which is located 250 metres higher. Two large sand traps and an afterbay reservoir complete the infrastructure.

**TECHNICAL SPECIFICATIONS**

**AFTERBAY RESERVOIR**
- **CAPACITY** 80,000 m$^3$

**PUMPING STATION**
- **POWER** 3 x 8.8 MW
- **FLOW RATE** 9.9 m$^3$/s
- **DISCHARGE HEAD** 212 m
- **TRANSFORMERS** 4 x 9.5 MVA (single phase) – 130 / 5 KV
Compensating basin
of 60,000 m³ capacity,
max. water level 2210 m

Z'Muttbach

EMBANKMENTS
DAM
INTAKE
FORE CANAL
2 GRAVEL TRAPS
Q = 2 x 7.5 m³/s
GRAVEL TRAP PURGE TUNNEL
WINTER SUPPLY CANAL
INTAKE, EMPTYING AND OVERFLOW STRUCTURE
EMPTYING AND OVERFLOW TUNNEL
STILLING BASIN
BURIED 1.80 m Ø PENSTOCK, Q = 9.9 m³/s
BURIED 2.25 AND 2.45 m Ø SYPHON PIPE, Q = 21.3 - 31.2 m³/s
SYPHON EMPTYING AND PURGING STRUCTURE
END OF 130 kV LINE AND SUBSTATION
ACCESS ROAD
STREAM CONTROL STRUCTURES

Stafel pumping station

Stafel afterbay reservoir

Stafel pumping station

PLAN OF LOCATION
STAFEL PUMPING STATION
LONGITUDINAL AND TRANSVERSAL PROFILES OF CONDUITS

1. STRUCTURE AT TRANSITION FROM ROCK TO MORAINE
2. PASSAGE UNDER STREAM
3. SYPHON EMPTYING AND PURGING ARRANGEMENTS
4. ADIT
5. FURGG TUNNEL
6. BULKHEAD GATE
7. EARTHFILL EMBANKMENT
8. STAFEL COMPENSATING BASIN, USEFUL CAPACITY 80,000 m³
9. INTAKE
10. 2 GRAVEL TRAPS
   Q = 2 x 7.5 m³/s
11. MORAINE
12. STEEL LINING
13. REINFORCED GUNITE

LONGITUDINAL PROFILE OF SYPHON

LONGITUDINAL PROFILE OF BURIED PIPELINE BETWEEN BASIN AND PUMPING STATION
STAFEL PUMPING STATION
INSTALLATION PLANS

CROSS-SECTION A-A

LONGITUDINAL SECTION

PLAN OF PUMPING STATION

1. MACHINES HALL
2. CONTROL ROOM
3. 5 kV SWITCHGEAR
4. TRANSFORMERS
5. PUMPS
6. MOTORS
7. 3 0.70 m Ø VALVES
8. UNTANKING AREA
9. 20 kV STANDBY TRANSFORMER FOR STATION AUXILIARIES
10. 0.50 m Ø BY-PASS VALVE WITH ENERGY DISSIPATOR
11. 0.40 m Ø PENSTOCK EMPTYING VALVE
12. 2.45 m Ø SYPHON
13. AUXILIARIES
14. OVERHEAD CRANE
Located deep in the Hérens valley (alt. 1896 m), the Ferpècle pumping station collects the water from the Ferpècle and Mont Miné glaciers. Every year, 3 pumps transfer around 60 million m$^3$ of water up the 212-metre gulley to the Arolla pumping station via the Maya reservoir. The total output from the facility is 8.4 m$^3$/second.

The power station is hidden inside the mountain. Only a dam, two sand traps and a gravel trap are visible. To prevent floodwater entering the installations, the Ferpècle water intake is equipped with a restrictor on the sand trap.

**TECHNICAL SPECIFICATIONS**

**AFTERBAY RESERVOIR**
- CONSTRUCTION: 1962 - 1964
- HEIGHT: 25.5 m
- CREST: 91 m
- VOLUME OF CONCRETE: 6000 m$^3$
- CAPACITY: 100,000 m$^3$
- SURFACE AREA: 11ha
- TYPE: Arch dam

**PUMPING STATION**
- POWER: 3 x 7.1 MW
- FLOW RATE: 8.4 m$/s$
- DISCHARGE HEAD: 212 m
FERPÈCLE PUMPING STATION

PLAN OF LOCATION

1 WATER INTAKE IN THE RIVER
2 INTAKE, Q = 11 m³/s
3 2 SAND TRAPS
4 25.5 m HIGH ARCH DAM
5 SPILLWAY TUNNEL, Q = 200 m³/s
6 DEWATERING AND OVERFLOW TUNNEL
7 1.90 m STEEL-LINED SUPPLY TUNNEL TO PUMPING STATION
8 UNDERGROUND PUMPING STATION
9 INCLINED DELIVERY SHAFT
   GRADIENT 80 %, 1.55 m Ø,
   Q = 8.4 m³/s
10 BOTTOM STATION GALLERY
11 STATION ACCESS TUNNEL
12 STATION ACCESS BRIDGE
13 ACCESS ROAD TO SERVICE BUILDING
14 SERVICE BUILDING
15 MOURTI DIVERSION PIPE 0.25 m Ø,
   Q = 0.15 m³/s
16 SUBSTATION
17 LES HAUDÈRES-FERPÈCLE
18 130 kV LINE
19 POWER STATION WATER INTAKE

Ferpècle afterbay reservoir in the Hérens valley.
FERPÈCLE PUMPING STATION
LONGITUDINAL AND TRANSVERSAL PROFILES OF CONDUITS

1. TWO 2 x 5.5 m³/s SAND TRAPS
2. POWER STATION WATER INTAKE
3. FERPÈCLE SERVICE BUILDING
4. ACCESS TO LIFT
5. FERPÈCLE PUMPING STATION
6. SUPPLY TUNNEL, Q = 8.4 m³/s
7. DELIVERY SHAFT, Q = 8.4 m³/s
8. ADIT
9. VEISIVI TUNNEL
10. WATER INTAKE IN THE RIVER
11. PURGE FLUME
12. COMPENSATING BASIN, USEFUL CAPACITY 100,000 m³
FERPÈCLE PUMPING STATION
INSTALLATION PLANS

CROSS-SECTION B-B

LONGITUDINAL SECTION A-A

1 CONTROL ROOM
2 MACHINES HALL
3 LOW-PRESSURE VALVES GALLERY – THREE 0.80 m Ø VALVES
4 THREE 7800 kVA TRANSFORMERS – 130 / 5 kV
5 SUPPLY TUNNEL, Q = 8.4 m³/s
6 DELIVERY SHAFT, Q = 8.4 m³/s
7 SCOUR TUNNEL
8 Dewatering TUNNEL
9 VENTILATION TUNNEL
10 SHAFT FOR LIFT TO SERVICE BUILDING AND 130 kV CABLES
11 130 kV CABLES
12 5 kV BUSBAR GALLERY
13 25 TON OVERHEAD TRAVELLING CRANE
14 THREE 0.625 m Ø HIGH-PRESSURE VALVES
15 STORES
16 LOW WATER PIT
17 DISTRIBUTOR
18 WORKSHOPS
19 APARTMENT

PLAN VIEW OF PUMPING STATION
Compensating basin
useful capacity 10000m³
max. water level 1894.50 m

1. ABUTMENT
2. PENDULUM OBSERVATION CHAMBER
3. INVERTED PENDULUM SHAFT
4. WATER INTAKE
5. BOTTOM SLUICE
6. OVERFLOW WEIR
7. ROADWAY
8. RAMP TO BOTTOM OF BASIN
9. TRANSVERSAL CONTRACTION JOINTS
After the Z’Mutt pumping station, Arolla is the most powerful station at the Grande Dixence site. It receives the water already pumped via Ferpècle, supplementing it with water from the Tsidjore Nouve and Bertol glaciers. The Arolla facility collects and discharges around 90 million m$^3$ of water every year. Three 16.2 MW dual-inlet pumps each transfer 4.2 m$^3$ of water per second a height of 312 metres.

**TECHNICAL SPECIFICATIONS**

**MAYA AFTERBAY RESERVOIR**
- **CAPACITY** 17,300 m$^3$

**PUMPING STATION**
- **POWER** 3 x 16.2 MW
- **FLOW RATE** 12.6 m$^3$/s
- **DISCHARGE HEAD** 312 m
AROLLA PUMPING STATION
PLAN OF LOCATION

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<th>No.</th>
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<tr>
<td>1</td>
<td>FERPÈCLE SUPPLY TUNNEL, GRADIENT 2.9%, Q = 8.4 m³/s</td>
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<td>2</td>
<td>LOWER BERTOL SUPPLY TUNNEL, Q = 2.0 m³/s</td>
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<td>3</td>
<td>OVERFLOW SYPHON</td>
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<td>4</td>
<td>COMPENSATING CHAMBER, DEWATERING AND SCOUR VALVES</td>
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<td>5</td>
<td>DEWATERING, SCOUR AND OVERFLOW TUNNEL</td>
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<tr>
<td>6</td>
<td>ACCESS TUNNEL</td>
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<td>7</td>
<td>ACCESS TO VEISIVI TUNNEL</td>
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<td>8</td>
<td>1.80 m Ø STEEL-LINED SHAFT TO PUMPING STATION, GRADIENT 80%</td>
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<td>9</td>
<td>ROCK TO MORAINE TRANSITION STRUCTURE</td>
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<td>10</td>
<td>1.80 m Ø BURIED SUPPLY PIPE</td>
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<td>11</td>
<td>CULVERT UNDER THE BORGNE</td>
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<td>12</td>
<td>SUPPLY PIPE DEWATERING AND SCOUR VALVES</td>
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<td>13</td>
<td>TSIDJIORE-NOUVE BURIED SUPPLY PIPE, Q = 2.0 m³/s</td>
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<td>14</td>
<td>PIPE DEWATERING AND SUPPLY VALVES</td>
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<td>15</td>
<td>1.65 m Ø BURIED DELIVERY PIPE</td>
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<td>16</td>
<td>130 kV LINE</td>
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<td>17</td>
<td>SUBSTATION</td>
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<td>18</td>
<td>AROLLA P4 CABLEWAY (ACCESS TO MAIN UPPER TUNNEL)</td>
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<td>19</td>
<td>AROLLA-BERTOL ROAD</td>
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<td>20</td>
<td>BRIDGE</td>
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Compensating chamber
useful capacity 25 000m³
max. water level 2084.00 m

Arola pumping station machines room
The top of the dam offers an astounding 360° panorama.

**STORAGE**

The water collected by the conveyance network is stored behind the Grande Dixence dam. Grande Dixence has a capacity of 400 million m$^3$. Its 285-metre wall makes it the tallest gravity dam in the world. The structure is made from 6 million m$^3$ of concrete and weighs 15 million tonnes. It is 200 metres wide at the base and 15 metres wide at the crest. The two shores are 700 metres apart at the crest. Inside the wall of the dam, there are 32 kilometres of tunnels and inspection chambers which allow the dam supervisors to continuously inspect the facility.
Towering above the Val des Dix, Grande Dixence holds many records. The gravity dam’s 285-metre wall remains the tallest in the world. At around 15 million tonnes, it is heavier than the Great Pyramid of Cheops.

To contain the more than 400 million m$^3$ of water stored each year, no fewer than 6 million m$^3$ of concrete were laid between the mountains. The same amount of concrete could be used to build a 1.5-metre high, 10-centimetre wide wall right around the equator!

The dam is 200 metres wide at its base. As it rises, it tapers to a width of 15 metres. A 200-metre deep grout curtain surrounds the dam to make the soil foundation watertight. It penetrates 100 metres into the valley sides.

The wall itself is made up of 16 m square concrete blocks jointed together so as to ensure maximum cohesion, strength and impermeability.

**TECHNICAL SPECIFICATIONS**

**GRAVITY DAM**

<table>
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<tr>
<th>Specification</th>
<th>Value</th>
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<td>CONSTRUCTION</td>
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<td>COMMISSIONED</td>
<td>in 1961</td>
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<td>HEIGHT</td>
<td>285 m</td>
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<td>CREST</td>
<td>15 m wide, 700 m from one side to the other</td>
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<td>VOLUME OF CONCRETE</td>
<td>5,960,000 m$^3$</td>
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<td>LENGTH OF INSPECTION TUNNELS</td>
<td>15,200 m</td>
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<td>LENGTH OF INJECTION WELLS</td>
<td>14,500 m</td>
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<td>CAPACITY OF RESERVOIR</td>
<td>400,000,000 m$^3$</td>
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<td>SURFACE AREA OF RESERVOIR</td>
<td>4.04 km$^2$</td>
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<td>LENGTH OF RESERVOIR</td>
<td>5.3 km</td>
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<td>LENGTH OF BASE TUNNELS, DRAINAGE TUNNELS AND THALWEG</td>
<td>2160 m</td>
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</table>
1. Water intake and main discharge inlet
2. Guard gate 3.00 m Ø
3. Headrace tunnel to the Fionnay power plant
   Q = 45 m³/s
4. Pressure reducing systems for the old Chandoline installations
5. Headrace tunnel to the Chandoline power plant (ALPIQ)
   Q = 10.25 m³/s
6. Main discharge inlet
   Q = 35 m³/s
7. Reduction system regulation well and inflow of water from Cleuson (ALPIQ)
8. Headrace tunnel for water from Cleuson
   Q = 2.7 m³/s
9. Sand trap – gravel trap for water from Cleuson
10. Shield for direct introduction of water from Cleuson into the reservoir
    (lake below 2240.50)
11. Inlet structure for bottom outlet
12. Valves chamber and bottom outlet tunnel
    Q = 10 m³/s
13. Headrace tunnel for water from Chenaz
    Q = 1.5 m³/s
14. Headrace tunnel for water from Vouasson
    Q = 1.6 m³/s
15. Opening in the old dam
16. Transverse dam contraction joints every 16 m
17. Operations building (RITZ)
18. Heliport
19. Access tunnel to valves and pressure reducing systems
20. Underground workshop and substation 65 kV
21. Chargeur-Blava cable car
22. Visitor platform
23. Motôt-Chargeur-Blava road
24. Old decommissioned tunnel
25. Old decommissioned service funiculars
26. Mirador
27. Pasture tracks to Cheilon
28. Measurement station for water from Vouasson
29. Measurement station for water from Cleuson
30. Measurement station for water from Chenaz
31. Headrace tunnel to the Bieudron power plant
    Q = 75 m³/s
32. Valve chamber
    Cleuson-Dixence
1. Water intake and main discharge inlet
2. Upstream face of dam
3. Removable shield for inflow of water from Cleuson into the reservoir (Lake below 2240.50)
4. Cleuson tunnel (ALPIQ)
5. Dix-Bagnes tunnel
6. Guard gate, 3.00 m Ø
7. Butterfly valve, 1.40 m Ø
8. 2 pressure reducing systems, 3.00 m Ø, length 18.00 m
9. 2 main discharge valves, 0.75 x 1.40 m
10. Bulkhead gate, 1.40 x 1.00 m
11. Reduction system regulation well and inflow of water from Cleuson (ALPIQ)
12. Plug and watertight door
13. Main discharge tunnel
14. Inflow of water from Cleuson (ALPIQ)
15. Access tunnel
16. Workshop, underground store and substation 65 kV
17. Decommissioned tunnel section
18. 2 bulkhead gates, 3.00 x 2.00 m
19. Valves control room
20. Valve chamber
21. Axis of dam
22. Chargeur-Tracouet headrace tunnel
23. Cleuson-Dixence butterfly valve chamber, 3.30 m Ø
24. Bieudron water intake

400 million m³ of water, ready to drive the turbines
GRANDE DIXENCE DAM
FALL OUTLETS AND MAIN DISCHARGE INLET

1. MAIN DISCHARGE INLET
   VALVES CHAMBER
2. VENT PIPE
3. DIX-BAGNES TUNNEL
4. 2 SLIDE VALVES, 140 x 0.75 m
5. REDUCING SYSTEM I
6. REDUCING SYSTEM II
7. MAIN DISCHARGE INLET
   Q = 35 m³/s
8. AFTERBAY CHAMBER WITH SPIRAL RAMP FOR DIRECT INFLOW OF WATER FROM CLEUSON INTO THE PRESSURE REDUCING SYSTEM REGULATION SHAFT
9. ACCESS TUNNEL
10. REGULATION SHAFT, ø 1.80 m
11. INFLOW OF WATER FROM CLEUSON SPIRAL RAMP
12. SERVICE WALKWAY
13. BYPASS VALVE
14. THRESHOLD SPILLWAY
15. BUTTERFLY VALVE, ø 140 m
16. NEEDLE VALVE
17. VALVE CHAMBER
18. BULKHEAD GATE, 140 x 1.00 m
19. TUNNEL TO CHANDOLINE

LONGITUDINAL PROFILE B-B, REFERS TO PLAN OF LOCATION P.64

LONGITUDINAL PROFILE C-C, REFERS TO PLAN OF LOCATION P.64
GRANDE DIXENCE DAM
DEVELOPED LONGITUDINAL CROSS-SECTION OF THE DAM

1 DEVELOPED LENGTH
APPROX. 695 m
2 DIRECTION CHANGE PLAN VIEW
3 MAIN ACCESS
TO THE BOTTOM TUNNEL
4 OLD CLEUSON TUNNEL CLOSED
BY A CONCRETE PLUG
5 MINIMUM LEVEL 2215.00
6 1.50 m Ø SHIELD FOR DIRECT INFLOW
OF WATER FROM CLEUSON (ALPIQ)
INTO THE RESERVOIR
7 WATER INTAKE AND MAIN
DISCHARGE INLET
(AXIS ALTITUDE 2163.93)
8 INLET STRUCTURE
FOR BOTTOM OUTLET
9 BOTTOM TUNNEL
HEIGHT 3.50 m, WIDTH 2.50 m
10 LONGITUDINAL INSPECTION TUNNEL
HEIGHT 2.50 m, WIDTH 1.50 m,
DISTANCE BETWEEN TUNNELS 16 m
11 COOLING AND INJECTION SHAFT,
1.90 m Ø
12 GROUND PROFILE AT THE AXIS
OF THE BOTTOM TUNNEL
13 GROUND PROFILE
AT THE UPSTREAM FACE
14 GROUT CURTAIN DRILLING
AND INJECTION TUNNEL
15 CLEUSON-DIXENCE
WATER INTAKE
GRANDE DIXENCE DAM
CALCULATED CONSTRAINTS AND EFFECTIVE METERING

LOAD SCENARIO
- Ordinary load scenario: lake empty or full, safety coefficient varying between 2.55 and 3.80 (on cyl.) based on dispersions obtained for the results of the concrete tests.
- Exceptional load scenario: lake empty or full and earthquake, safety coefficient 2.25 (on cyl.)
- Constraint concentrations at end of footings: lake empty or full and earthquake, safety coefficient 1.75 (on cyl.)

CONCRETE METERING
Metering indicated in kg of normal Portland cement per m$^3$ of finished concrete (kg/m$^3$)

- 140 kg/m$^3$
- from 141 to 160 kg/m$^3$
- from 161 to 180 kg/m$^3$
- from 181 to 200 kg/m$^3$
- from 201 to 220 kg/m$^3$
- from 221 to 240 kg/m$^3$
- from 241 to 260 kg/m$^3$
- from 261 to 280 kg/m$^3$
- from 281 to 300 kg/m$^3$
GRANDE DIXENCE DAM

BOTTOM OUTLET

WATER INTAKE AND MAIN DISCHARGE INLET

LONGITUDINAL CROSS-SECTION B-B

HORIZONTAL CROSS-SECTION A-A

1 INLET STRUCTURE
2 PROVISIONAL INLETS
3 BOTTOM TUNNEL
4 THALWEG TUNNEL
5 VALVES CHAMBER ACCESS SHAFT
6 VALVES CHAMBER
7 VENT
8 BOTTOM OUTLET EVACUATION TUNNEL LENGTH APPROX. 505 m
9 GABIONS
10 AXIS OF DAM
11 UPSTREAM FACE OF DAM
12 CONDUIT, Ø 0.60 m
13 SHIELDED AIRLOCK
14 LONGITUDINAL JOINT
15 AXIS OF THE DAM
16 UPSTREAM FACE
17 CONCRETE TRAINING WALLS
18 AXIS OF BLOCK XXIV
19 TRANSVERSE JOINT N° 48
20 TRANSVERSE JOINT N° 46

1 GRIDS
2 BULKHEAD GATE CONTROL CHAMBER
3 HORIZONTAL INSPECTION TUNNEL
4 ACCESS TUNNEL
5 BYPASS VALVE ACCESS SHAFT
6 BYPASS VALVE, 0.25 m Ø
7 SEALED CASING
8 BYPASS 0.25 m Ø
9 2.00 x 3.00 m BULKHEAD GATE SEAL INSPECTION SHAFT
10 INSPECTION CHAMBER
11 DRAIN 0.25 m Ø
12 VENT 0.25 m Ø
13 TRANSVERSE JOINT N° 46
14 TRANSVERSE JOINT N° 48
15 AXIS OF THE DAM
16 UPSTREAM FACE
17 CONCRETE TRAINING WALLS
18 AXIS OF BLOCK XXIV
19 TRANSVERSE JOINT N° 48
20 TRANSVERSE JOINT N° 46
PRODUCTION

The water stored behind the Grande Dixence dam is transferred as required to the three surrounding underground power plants: Fionnay, Nendaz and Bieudron. These power plants represent a total of 2000 MW and produce around 2 billion kWh every year. Once it has passed through the turbines, the water is returned to the Rhône.
The water held behind the Grande Dixence dam is transformed into electricity in two stages. The first stage takes place at the Fionnay underground power plant. An underground and gently sloping tunnel stretching over nine kilometres had to be constructed to carry the water to the turbines.

The surge chamber, which is located at Louvie in the Val de Bagnes, becomes a penstock which descends 800 metres at a gradient of 73%. The penstock runs to the distributor at the Fionnay facility, a vast cavern hollowed out of the rock.

**TECHNICAL SPECIFICATIONS**

**AFTERBAY RESERVOIR**

CAPACITY  166,000 m³

**POWER PLANT**

NUMBER OF TURBINES  6 x 2 Pelton
INSTALLED POWER CAPACITY  290 MW
FLOW RATE  45 m³/s max.
MAX. DROP HEIGHT  873.8 m
MIN. DROP HEIGHT  679.8 m
TRANSFORMERS  9 x 40 MVA (single phase) – 220 / 15 KV
FIONNAY POWER PLANT

PLAN OF LOCATION

1. LOUVIE STEEL-LINED SHAFT: 3 to 2.80 m Ø, Q = 45 m³/s
2. VALVES CHAMBER
3. MACHINES HALL
4. TRANSFORMERS AND HIGH VOLTAGE SWITCHGEAR CHAMBERS
5. SURFACE SERVICE BUILDING
6. ACCESS TUNNEL AND TAILRACE TUNNEL ONE ABOVE THE OTHER
7. TAILRACE TUNNEL
8. TAILRACE TUNNEL OVERFLOW SYPHON AND OUTLET SHAFT
9. TAILRACE TUNNEL OUTLET INTO TAILPOND AND NENDAZ POWER PLANT INTAKE
10. NENDAZ TUNNEL SHUT-OFF VALVE: 3.00 m Ø
11. 4.10 m Ø VERTICAL SHAFT AND SUPPLY TUNNEL TO NENDAZ POWER PLANT INTAKE: Q = 45 m³/s
12. TAILPOND DIVERSION, DISCHARGE AND OVERFLOW STRUCTURE
13. OUTLET TUNNEL FROM STRUCTURE 12
14. EXCHANGE TUNNEL BETWEEN FORCES MOTRICES DE MAUVOISIN (FMM) AND GRANDE DIXENCE (GD)
15. FMM TAILPOND DISCHARGE TUNNEL
16. DEWATERING STRUCTURE WITH PUMP
17. CHAMPSÉC POWER PLANT INTAKE
18. SUPPLY TUNNEL TO CHAMPSÉC POWER PLANT (FMM)
19. ORIGINAL RIVER BED IN TAILPOND
20. ACCOMMODATION FOR PERSONNEL
21. WINTER ACCESS TUNNEL TO PLANT
22. CABLEWAY TO LOUVIE SHAFT SHUT-OFF VALVE
23. AVALANCHE PROTECTIONS
24. FIONNAY-CHAMOSON 220 kV LINE
25. FIONNAY-LOURTIER ROAD
26. GD TAILPOND: LIVE CAPACITY: 166,000 m³; MAXIMUM LEVEL 1486.00
27. FMM TAILPOND
FIONNAY POWER PLANT
INSTALLATIONS PLANS

3  CONTROL ROOM FOR SETS V AND VI
4  MACHINES HALL
5  VALVES GALLERY
6  2 x 0.80 m Ø SPHERICAL VALVES
7  10 x 0.65 m Ø SPHERICAL VALVES
11  DISTRIBUTOR
14  15 kV SWITCHGEAR
15  TRANSFORMERS CHAMBER
16  220 kV SWITCHGEAR
29  TAILRACE TUNNEL
32  2 x 70 TON OVERHEAD TRAVELLING CRANES
34  TURBINES PIT
41  25 TON OVERHEAD TRAVELLING CRANE
42  VENTILATION TUNNEL
43  NOZZLE
44  GENERATOR
45  GOVERNOR
46  SERVICE GALLERY
47  DRAINAGE GALLERY AND COOLING WATER PIPES
48  COOLING PIPES
49  TURBINES

TRANVERSE CROSS-SECTION A-A, REFERS TO THE HORIZONTAL CROSS-SECTION P.83

TRANVERSE CROSS-SECTION B-B, REFERS TO THE HORIZONTAL CROSS-SECTION P.83
After passing through the turbines at Fionnay, the water from Grande Dixence is transferred to the Nendaz power plant. It enters a pressure tunnel which leads to the Péroua surge chamber 1000 metres above the power plant. The tunnel linking Fionnay and Nendaz is 16 kilometres long. At its end is a penstock.

Deep in the mountain between Aproz and Riddes, the Nendaz power station is – after the Bieudron plant – the largest hydroelectric power plant in operation in Switzerland. It operates on the cascade principle with the Fionnay power station, which means its capacity and output are regulated by the latter.

**TECHNICAL SPECIFICATIONS**

**POWER PLANT**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER OF TURBINES</td>
<td>6 x 2 Pelton</td>
</tr>
<tr>
<td>INSTALLED POWER CAPACITY</td>
<td>390 MW</td>
</tr>
<tr>
<td>FLOW RATE</td>
<td>45 m³/s max.</td>
</tr>
<tr>
<td>MAX. DROP HEIGHT</td>
<td>1007.8 m</td>
</tr>
<tr>
<td>MIN. DROP HEIGHT</td>
<td>1001.8 m</td>
</tr>
<tr>
<td>TRANSFORMERS</td>
<td>6 x 80 MVA (three-phase) – 220 / 13 KV</td>
</tr>
</tbody>
</table>
NENDAZ POWER PLANT

PLAN OF LOCATION

1. NENDAZ SHAFT, STEEL-LINED, 2.90 m Ø, Q = 45 m³/s
2. VALVES GALLERY
3. MACHINES HALL
4. TAILRACE CANAL
5. TAILRACE CANAL BULKHEAD GATE
6. 220 kV CABLES TUNNEL FOR SETS I TO III
7. CABLES BRIDGE FOR SETS I TO III
8. PLANT ACCESS TUNNEL AND CABLES ROUTE FOR SETS IV TO VI
9. BRIDGE OVER RHÔNE AND CABLES ROUTE FOR SETS IV TO VI
10. SERVICE BUILDING, WORKSHOP, UNTANKING ROOM AND ENTRANCE TO PLANT
11. GARAGES
12. MAIN STORE AND VEHICLES WORKSHOP
13. PROTECTIVE FILL
14. SUBSTATION SERVICE BUILDING WITH CONTROL ROOM
NENDAZ POWER PLANT
OVERALL LONGITUDINAL PROFILE AND TRANSVERSE PROFILE

1.80 m Ø BIFURCATION FOR CHANDOLINE (ALPIQ)
Q = 10.25 m³/s
AND MAIN DISCHARGE
Q = 35.00 m³/s

2.90 m Ø INCLINED STEEL-LINED SHAFT, LINING THICKNESS
16 - 22 mm, BANDED

5. LOUVIE SURGE CHAMBER 70 %
SLOPE, 13 - 23 mm THICK STEEL LINING TO ELEVATION 2301 m

2.90 m Ø BUTTERFLY VALVE

7. STEEL-LINED SHAFT VARYING FROM 3 TO 2.80 m Ø, SLOPE 73 %

8. FIONNAY POWER PLANT, MAXIMUM GROSS HEAD: 873.8 m,
MAXIMUM DISCHARGE: 45.0 m³/s,
INSTALLED CAPACITY: 290 MW

9. 2 x 2.82 m Ø SLIDE GATES

10. FIONNAY TAILPOND
CAPACITY 166,000 m³

11. 3.00 m Ø BUTTERFLY VALVE FROM 8 - 12 mm THICK STEEL LINING IN LINED ZONE

12. 4.10 m Ø VERTICAL SHAFT

13. SARREYER ADIT, LENGTH 1219.97 m

14. ISÉRABLES ADIT A)
LENGTH 512.47 m

15. FARA INTAKE, Q = 1.00 m³/s

16. ISÉRABLES ADIT B)
LENGTH 512.47 m

17. PÉROUA SURGE CHAMBER, STEEL-LINED TO ELEVATION 1450.00 m

18. VALVE CHAMBER

19. 3.00 m Ø BUTTERFLY VALVE

20. 3.10 m Ø PENSTOCK

21. ANCHOR BLOCKS

22. 2.90 m Ø VERTICAL STEEL-LINED SHAFT

23. 2.90 m Ø INCLINED STEEL-LINED SHAFT, LINING THICKNESS
16 - 22 mm, BANDED

24. NENDAZ POWER PLANT,
MAXIMUM GROSS HEAD: 1007.8 m,
MAXIMUM DISCHARGE: 45.0 m³/s,
INSTALLED CAPACITY: 390 MW

25. TAILRACE CANAL

26. WALKWAY AND BRIDGE FOR 220 kV CABLES

27. 220 kV SUBSTATION
The Bieudron facility is Switzerland’s most powerful hydroelectric power plant. The underground power station, which is adjacent to the Nendaz power plant, was built between 1993 and 1998 to more than double the power capacity of the Grande Dixence complex. It can inject as much power as a nuclear power station into the grid in just a few minutes! The Bieudron power plant holds three world records: the drop height (1883 m), the power per Pelton turbine (3 x 423 MW) and the power per generator pole (35.7 MVA).

**TECHNICAL SPECIFICATIONS**

**POWER PLANT**
- **NUMBER OF TURBINES**: 3 Pelton
- **INSTALLED POWER CAPACITY**: 3 x 423 MW
- **POWER PER GENERATOR POLE**: 3 x 35.7 MVA
- **FLOW RATE**: 75 m³/s max.
- **MAX. DROP HEIGHT**: 1883 m
- **TRANSFORMERS**: 3 x 465 MVA (three-phase) – 410 / 21 KV

**FOR MORE INFORMATION ON THE BIEUDRON POWER STATION:**
CLEUSON - DIXENCE DISCOVER A HYDROELECTRIC FACILITY UNIQUE IN THE WORLD
Technical brochure, 44 pp.
BIEUDRON POWER PLANT

PLAN OF LOCATION

1. NENDAZ PLANT, 390 MW
2. PENSTOCK INLET, 75 m³/s
3. DISTRIBUTOR, 3 x 25 m³/s
4. SPHERICAL VALVES CHAMBER
5. BIEUDRON MACHINES ROOM
6. BAR TUNNELS
7. TRANSFORMER CELLS
8. COOLING WATER RESERVOIR, CAPACITY 21,000 m³
9. TAILRACE TUNNEL
10. 410 kV CABLES TUNNEL AND ACCESS TO TRANSFORMERS
11. RESTITUTION WORK TO THE RIVER RHÔNE
12. CABLES GATEWAY
13. CHAMOSON SWITCHING STATION (410/230 kV)
14. CONNECTING TUNNELS
15. EMERGENCY TUNNEL
16. VENTILATION TUNNELS
17. ACCESS TUNNELS COMMAND AND CONTROL SYSTEM FOR SWITCHING STATION
18. AUTO-TRANSFORMER (600 MVA / 230 / 410 kV)
19. RESTITUTION WORK TO THE RIVER RHÔNE
20. CABLES GATEWAY

INSTALLATIONS PLAN

1. GENERATOR SHAFT
2. EXCITER
3. ROTOR – COOLING WATER
4. ROTOR
5. STATOR
6. TURBINE GUIDE BEARING
7. PELTON TURBINE
8. RACK AND PLATFORM
9. INJECTOR
10. BUSBARS
11. COMBINED TRUST AND BEARING SUPPORT
BIEUDRON POWER PLANT
INSTALLATIONS PLANS

1. EXCITER
2. GENERATOR
3. PELTON TURBINE AND INJECTOR
4. RACK AND PLATFORM
5. BUSBARS

1. DISTRIBUTOR
2. VALVES CHAMBER
3. 250 TONS OVERHEAD CRANE
4. MACHINES ROOM
5. TUNNEL FOR LOW AND MEDIUM VOLTAGE CABLES
6. LOW WATER TUNNEL
7. BAR TUNNEL
8. FLAP GATE
9. TAILWATER BRANCH
10. TRANSFORMER CELLS
11. TAILRACE
The crest of the Grande Dixence dam is the starting point for many a beautiful mountain walk.

**INFORMATION**

For many years, Grande Dixence SA has welcomed visitors to its dam, as well as its pumping and power stations. The Grande Dixence dam is open to visitors from mid-June to the end of September. Four guided tours inside the wall take place every day. The pumping and power stations on the Grande Dixence complex can be visited on every working day of the year (for more information, visit www.grande-dixence.ch).
The energy produced by Grande Dixence SA is supplied in its entirety to the four partner companies which have the share capital of the company (300 million CHF), i.e.:

60%  
ALPIQ SUISSE SA, LAUSANNE

13 1/3%  
AXPO POWER AG, BADEN

13 1/3%  
BKW ENERGIE AG, BERNE

13 1/3%  
IWB INDUSTRIELLE WERKE BASEL, BÂLE

- **Elektrizitätswerk Zermatt AG (EWZ)**, industrial services for the municipality of Zermatt, with 45% of the share capital held since November 2001. This partnership has allowed EWZ and Grande Dixence SA to develop synergies to exploit and process the water in the Zermatt basin.

- **HYDRO Exploitation SA**, created in June 2002 jointly by EOS Holding and FMV SA, to manage their installations. Grande Dixence SA holds 35% of the share capital. Established in 2003, HYDRO Exploitation SA was one of the first companies to focus entirely on the use of hydroelectric energy. Primarily designed for its shareholders, the company's services could also be offered to the owners of other hydraulic facilities in Valais or elsewhere.

- **Cleuson-Dixence**, an ordinary partnership created jointly with EOS in 1992 to increase the capacity for electricity production. Grande Dixence SA's holding is 15/22.

- **Forces Motrices de la Borgne SA (FMdB)**, with 29% of the share capital since January 2009. FmdB owns the Bramois development, located downstream of the Grande Dixence installations, and uses the waters of the Borgne river. FmdB's other shareholders are the communes of Hérémence, St-Martin, Vex, Mont-Noble and Sion (51%) and the company FMV SA (20%).