CREATIVE POWER

CONSTRUCTION OF HYDRO POWER PLANTS
CONSTRUCTION
OF HYDRO POWER
PLANTS
Today, production of electric energy using renewable hydro-energy resources is a major nature protection and resource-saving technology in the world.

Although the development of the entire hydro-energy potential of the world cannot cover the projected growth of the need for the electric power, it’s hydropower installations, which are going to replace some of the thermal power plants. Construction of hydro power plants allows us not only to considerably reduce the emission of pollutants into the environment, but also to reduce the use of nonrenewable natural resources, such as oil and gas, which can be used for other purposes.

Simultaneously with the solution of the primary goal, which is production of the electric energy, commissioning of hydro power plants helps to resolve many other problems, for example, water supply, irrigation, flood protection, etc.

According to the World Energy Council, about 33 % of the planet water resources have been developed. However, despite this fact, the hydropower potential of the majority of the countries of Europe and North America is almost exhausted. More than 90 % of the available hydropower potential have already been developed in France, Switzerland, and Austria; 65 to 90 % – in Japan, Germany, and Sweden; 45 to 65 % – in the USA, Canada, Brazil and Spain; and 20-45 % – in China, India, and Argentina.

And only undeveloped water-energy resources of Africa, Asia and South America open wide opportunities for building new hydro power plants. Africa, possessing 21 % of the world water-energy resources and Asia (3 %) produce only 5 % and 18 %, respectively, of the world hydroelectric energy, and South America and Australia taken together with approximately 15 % of the resources, produce only 11 % of the hydroelectric energy in the world.
## Hydro Power Plants

### DESCRIPTION OF FACILITIES

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<th>Name of facility</th>
<th>Year of completion of construction</th>
<th>Country</th>
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<td>1. Hydro power plant “Kapanda”</td>
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<td>10. Aswan hydropower complex</td>
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<td>Egypt</td>
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</tbody>
</table>
SC «Technopromexport» is one of the leading engineering companies in Russia, which has been carrying out full scope of works in the area of power engineering facilities construction for more than half a century both in Russia and abroad.

Construction of hydro power plants is one of Technopromexport’s principal areas of activity.

For more than half a century, Technopromexport has accumulated vast experience in the area of hydraulic engineering installations construction. In more than 20 countries of Europe, Asia, Africa and Latin America, Technopromexport has successfully put in service more than 50 hydro power plants with the total installed capacity of 125,000 MW.

The range of the commissioned hydro power plants is as follows: from units of MW to the largest in Africa Aswan HPP, capacity 2,100 MW, in the ARE, «Khoabihn» HPP, capacity 1,920 MW, in Vietnam, and the Euphrates hydro-complex «Tabka», capacity 800 MW, in Syria.

During construction of a hydro power plant, Technopromexport manages all the stages of the project, and performs a complex of the facility building operations: design, construction and installation works including deliveries of the process and engineering equipment, and commissioning of the facilities. The corporate project management system allows Technopromexport specialists to monitor all the processes fully, construction and installation works, and also to make sure that the construction schedule is observed.

The complex of services offered by Technopromexport during construction of hydro power plants includes:

- Carrying out surveys, feasibility studies and design reviews;
- Delivery of complete power generating equipment;
- Building, installation, adjustment, and commissioning of facilities;
- Complex servicing of the constructed power engineering facilities including delivery of spare parts;
- Modernization and reconstruction of the power engineering facilities;
- Sharing experience, dispatching specialists and training of the local operating personnel both in the country of the Customer and in Russia.

Long-term experience of construction and designing of hydro power plants allows...
The established relations with the leading world equipment suppliers allow Technopromexport to deliver complete equipment with high technical-and-economic characteristics meeting the highest requirements of the energy market.

High quality of delivered design and equipment, and also implementation of the «turn-key» projects by Technopromexport have been demonstrated by 25 to 30 years of uninterrupted and trouble-free operation of the hydro power plants, such as the Aswan hydropower complex in the ARE, the «Dokan» HPP in Iraq, the “Iron Gates” HPP in Romania, the «Mulei Yusef» and «Mansur Eddahbi» HPP in Morocco and many other facilities.

The long-term experience and dozens of implemented projects are proved not only by the Technopromexport’s “Reference” sheet. With the growing prices of the hydrocarbon fuel and increasing energy consumption all over the world, many countries rely on Technopromexport’s vast expertise in the area of large-scale hydraulic engineering installations construction for researching the prospects for construction of hydraulic engineering installations.

The company also has vast experience in reconstruction of the operating hydro power plants, including the increase of the unit capacity. The reconstruction works are carried out not only on the hydro power plants commissioned by Technopromexport but also on the facilities erected by other companies.

Technopromexport also carries out complex delivery of equipment for turn-key construction of small hydro power plants with the unit capacity of up to 1 MW at a water head of 2 to 12 m.
## IMPLEMENTED PROJECTS

<table>
<thead>
<tr>
<th>Country</th>
<th>Name of facility</th>
<th>Power rating, MW</th>
<th>Year of completion</th>
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<td>“Puli Khumri” HPP</td>
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<td>“Kapanda” HPP</td>
<td>520</td>
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<td>Argentina</td>
<td>“Parana Medio” HPP</td>
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<td>Belarus</td>
<td>“Poltosk” HPP</td>
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<td>“Kydzhali” HPP</td>
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<td>Vietnam</td>
<td>&quot;Kan Don&quot; HPP</td>
<td>76</td>
<td>2006</td>
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</table>
Electromechanical equipment

Number of units — 4
Radial-axial turbine RO 115-V-425:
Capacity — 133 MW
Design head 84 m
Flow through the turbine is 160 cubic m/s
Generator SV 904/235-36TV4:
Capacity — 130 MW
Voltage — 13.8 kV
Hydro Power Plant “Kapanda”

It is one of the ten biggest hydraulic engineering installations on the African continent.

Was built on the Quanza River in the Republic of Angola; it is one of the ten biggest hydraulic engineering installations on the African continent. The “Kapanda” hydro power plant is the major supplier of electric energy in Angola, which produces 54% of all the electric energy in the country.

Installed capacity of the “Kapanda” HPP is 520 MW. Uniqueness of this hydraulic engineering installation consists in the fact that for the first time in the Russian experience, a concrete dam of a foreign hydraulic power system was designed based on high technology with the use of «rolled» concrete with reduced content of cement.

The annual average water flow on the hydraulic engineering installation site equals 19.69 cubic km from the catch water basin of 115 thousand sq. km. The maximum high-water flow at 0.01% probability is 9700 cubic m/s.

The volume of the «Kapanda» gravity dam is 1,100 thousand cubic meters of concrete, of which 75% is the rolled concrete. The 1.2-km dam having a height of 110 m has created a water reservoir of 4611 million cubic meters. The flood gate capacity is 7760 cubic m/s. It has four openings equipped with the hydraulic-driven segmented shutters. The water runs from the water inlet through four water lines to the hydroelectric unit turbines, capacity 130 MW. The complex of facilities also includes a substation of 220/110 kV. All electric energy is transmitted through the 200-kV line into the northern power supply system of Angola including the capital city of Luanda.
Hydro Power Plant “Dokan”

Electromechanical equipment:
- Number of units: 5
- Radial-axial turbine RO 115/810-V-330:
  - Capacity: 81.8 MW
  - Design head: 82 m
  - Flow: 109 cubic m/s
- Generator VGS 710/180-30 TS:
  - Capacity: 80 MW
  - Voltage: 13.8 kV

Year of completion: 2003

Location: Iraq, Middle East

Capacity: 400 MW
Hydro power plant "Dokan", capacity 400 MW, was built at an arch dam on the river Small Zab, the left tributary of the Tigris River in Iraq. The dam body has five water lines, diameter 3.65 m. These water lines have control butterfly valves in the upper part of the hydro power plant building.

The reservoir, capacity 6.8 cubic km, regulates the flow for the hydro power plant, which has five vertical hydraulic units, capacity 80 MW each. At a design head of 82 m, the hydraulic units generate 1.13 billion kWh of electric energy during a year of average water content.

The "Dokan" hydro power plant feeds power through the 132-kV gas-insulated switchgear to the industrial enterprises and the cities of Northern Iraq (Northern Kurdistan).
HYDRO POWER PLANT “YALI”

Electromechanical equipment:
- Number of units – 4
- Radial-axial turbine RO 230/791 DM1-V-360:
  - Capacity – 183.3 MW
  - Design head – 190 m
  - Flow – 104.4 cubic m/s
- Generator SV 735/255-24TV4:
  - Capacity – 180 MW
  - Voltage – 15.75 kV
- Control butterfly valve:
  - Diameter – 3,600 mm
  - Weight – 120 t
  - Design head – 250 m

HYDRO POWER PLANT “YALI”

VIETNAM

720 MW Capacity
4 units

SOUTH-EAST ASIA

Year of completion
2002

HYDRO POWER PLANT

VIETNAM

SOUTH-EAST ASIA

720 MW Capacity
4 units

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SOUTH-EAST ASIA

Year of completion
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  - Design head – 250 m

HYDRO POWER PLANT “YALI”

VIETNAM

SOUTH-EAST ASIA

Year of completion
2002
Second largest in capacity in Vietnam, hydro power plant «Yali» was built in the central part of the country on the Sesan River to cover the power needs in the central and southern parts of the country. Hydro power plant commissioning marked the completion of the next phase of the government program of energy supply in Vietnam including the central economic region of the country with population of more than 13 million people. The power engineering facilities include: diversion chamber with power canal; two diversion turbine supply tunnels, length – 3,750 m each; surge chambers; turbine conduits; underground powerhouse and transformer halls; diversion tunnels and canals; administrative-and-production complex; power output equipment; and the 500-kV outdoor switchgear.

The underground powerhouse hall including installation site is 118.5 m long, 21.0 m wide and 42.0 m high. Distance between the axes of the units is 10.8 m. The hydro power plant building accommodates radial-axial turbines, capacity 183.3 MW at design head of 190 m, and water flow of 104.4 cubic m/s through each turbine, and also with the generators, capacity 180 MW. The 720-MW hydro power plant generates 3.59 billion kW.h of electric energy during a year of average water content. The produced electric power is transmitted through the step-up transformers and the pressure oil cables to the 500-kV outdoor switchgear. Power transmission is carried out over two aerial lines to the «Pleiku» substation, and on, to the 500-kV North-South power transmission line.
HYDRO POWER PLANT “AL-VAKHDA”

MOROCCO

247 MW
Capacity

3 units

HYDRO POWER PLANT
“AL-VAKHDA”

MOROCCO
NORTH-WEST AFRICA

HYDRO POWER PLANT “AL-VAKHDA”

Electromechanical equipment
Number of units – 3
Radial-axial turbine RO 115/810-V-425:
Capacity – 82.6 MW
Design head – 61.8 m
Flow – 150 cubic m/s
Generator SV 900/155-42 TS4:
Capacity – 80 MW
Voltage – 10.5 kV

Year of completion
1998
Hydro power plant “Al-Vakhda” is located on the Uerga River in province Sidi-Kasem of Morocco. The “Al-Vakhda” HPP was built on the right bank of the river in the tail pond to cover the region’s electric power needs at full and peak loads, and also to regulate frequency in the network.

The hydro power plant is equipped with three radial-axial turbines, capacity 82.5 MW at design head of 61.8 and water flow of 150 cubic m/s through one turbine.

The “Al Vakhda” HPP, total capacity 247 MW, produces 400 million kW.h of electric power per year, with the power transmitted over three 225-kV power lines to the “Tetuans”, “Tulal” and “Duayet” substations. The HPP hydraulic units are remotely controlled from the central control station in Casablanca or independently controlled by the operators who monitor functioning of the hydraulic units.
HYDRO POWER PLANT
“KHOABHIN”

VIETNAM

1920 MW
Capacity

8
турбин

Hydro Power Plant
“KHOABHIN”

Electromechanical equipment

Number of units — 8
Radial-axial turbine RO 115/810-V-567.2:
Capacity — 245 MW
Design head — 88 m
Flow — 301.3 cubic m/s
Generator SV 1190/215-48TV4:
Capacity — 240 MW
Voltage — 15.75 kV

VIETNAM
SOUTH-EAST ASIA

HYDRO POWER PLANT
“KHOABHIN”

Year of completion 1994
Hydro Power Plant “Khoabhin”

«Khoabhin» hydro power plant is the largest in South East Asia erected on the Dha (Black) river in the northwestern part of Vietnam, 80 km from Hanoi, has already generated more than 80 billion kW-hours since the time of commissioning of the first unit out of its eight units in 1988. The hydro power plant plays and important role in the country economic development by providing about one third of all required electric energy in Vietnam. Besides, the «Khoabhin» HPP plays the key role in control of the water level on the rivers in the country northern regions. The power plant helps to solve such problems as control of high waters, irrigation of the northern agricultural regions, water supply, enhancing navigation in the lower reaches of the Dha and Red rivers, increasing the 200-km waterway up the river.

The HPP site is located up the city of Khoabhin, where the valley is narrowing to 250 to 300 m with the steepness of slopes of 25 to 30 degrees.

The hydro power plant facilities include: earth-and-rock-fill dam, water discharge facilities, hydro power plant, outdoor switchgear and the system of anti-seepage tunnels and cement joggles in carstified limestone in part of the dam adjacent to the left bank.

The «Khoabhin» HPP is an extremely difficult facility due to the combination of natural, industrial and operational conditions, such as: tropical climate with the annual total precipitation rate of 2000 mm, magnitude 8 seismicity, presence of karstic and landslide phenomena near the dam edges, and also permeable alluvial deposits of up to 60 m in the dam foundation on the channel section.

The earth-and-rock-fill dam, 734 m deep in the crest, with the maximum height of 128 m, has the loam central core and lateral downstream toes of hand-placed rocks. The dam forms a reservoir with capacity of 9.45 billion cubic meters.

The service spillway is a reinforced concrete buttress wall with six surface water discharge openings, 15 m in width, and twelve bottom discharges 6x10 m. The underground HPP, capacity 1,920 MW, with eight hydraulic units, capacity 240 MW each, generates 8.16 billion kWh of electric power a year.
HYDRO POWER PLANT “AL BAAS”

Electromechanical equipment

Number of units – 3
Tubular turbine PLGK 20/826-750:
Capacity – 27.2 MW
Design head – 7.0 m
Flow – 420 cubic m/s
Generator SGKVII 776/125 – 96:
Capacity – 27 MW
Voltage – 3.15 kV

SYRIA

MIDDLE EAST

1989

Capacity – 81 MW

SYRIA

Capacity – 81 MW

3 units
Hydro power plant “Al Baas” in Syria is located on the Euphrates River 26 km downstream from the Euphrates power engineering site. The HPP is designed to regulate the river flow and balance the daily water flow from the Euphrates HPP, and generate the electric power.

The HPP facilities include: 500-m long right bank embankment dam, the HPP building, the overflow dam with 8 flights, 14.5-m wide each, 750-m channel embankment dam, and the outdoor switchgear.

The HPP installations of total length of 3,200 m created a reservoir, capacity 90 million cubic m. The hydro power plant, capacity 81 MW, produces 375 million kW.h of the electric power a year. The HPP building accommodates three horizontal hydraulic units, capacity 27 MW at design head of 7 m.
Electromechanical equipment

Number of units — 4
Radial-axial turbine F-10:
   Capacity — 39.2 MW
   Design head — 297 m
   Flow — 15 cubic m/s
Generator NU 710/10:
   Capacity — 32.25 MW
   Voltage — 13.8 kV
Hydro power plant “Malka Vakana” in the Republic of Ethiopia is located in the upstream reach of the Uabi Shebelle River in the Ethiopian highlands near the equator, where seismicity reaches magnitudes 7 to 8. The annual average river flow in the hydraulic engineering installation site is 827 million cubic m, and the maximum high-water flow is 530 cubic m/s.

The terrain conditions of the region are favorable for creating a reservoir for the over-year regulation, capacity 763 million cubic m, and for installing a derivation hydro power plant. The hydraulic engineering facilities include: main facilities – the dam, the floodway gate and the bottom discharge, the diversion canal water inlet; the HPP diversion canal; the water inlet and the HPP penstock tunnel; the power plant center, and the 230-kV outdoor switchgear.

The earth-and-rock-fill dam with a length of 1,800 m and maximum height of 38 m is filled with local materials with the central loamy core and the rock apron slopes. The areal cement grouting and the cement-grout curtain to a depth of 25 to 30 m are provided in the dam foundation.

The automatic flood gate without shutters on the top edge of the discharge structure is designed for flood discharge with flows of up to 640 cubic m/s. The water diversion chute (horizontally curved) has a variable grade over the length and ends in a ski jump spillway, which dumps water into the river channel.

The water inlet of the HPP diversion canal is located on the right bank and is designed to feed water into the canal to operate four turbines at a rate of 60 cubic m/s.

The bottom discharge is designed for water passage from the reservoir at a rate of up to 30 cubic m/s.

The HPP intake channel is the main facility of the HPP penstock tunnel, which is arranged on the annular section of the diversion canal. Behind the nose, there is a reinforced-concrete pipe connecting the water inlet hole with the HPP penstock tunnel.

The HPP penstock tunnel consists of two sections: vertical tunnel to a depth of 298 m, and horizontal tunnel with a length of 535 m.

The power plant center, including the HPP building with the pressure inlet line, the tail-water channel and the site of generator transformers is located on a small site in a deep canyon.

Four Francis turbines, capacity 39.2 MW, and generators, capacity 38.25 MW at design head of 300 m, are installed in the power house.

The hydro power plant, capacity 153 MW, produces 543 million kWh of electric power to be transmitted through the 230-kV outdoor switchgear and via the 230-kV high voltage line to the electric power system.
HYDROPOWER COMPLEX ON THE EUPHRATES

Electromechanical equipment:

- Number of units – 8
- Kaplan turbine PL 70/642-V-600
- Capacity – 103 MW
- Design head – 40 m
- Flow – 285 cubic m/s
- Generator SV 1130/140-48Т:
  - Capacity – 100 MW
  - Voltage – 13.8 kV

SYRIA

800 MW Capacity
8 units

HYDROPOWER COMPLEX ON THE EUPHRATES

Year of completion: 1978

SYRIA

MIDDLE EAST

800 MW Capacity
8 units

HYDROPOWER COMPLEX ON THE EUPHRATES

Electromechanical equipment:

- Number of units – 8
- Kaplan turbine PL 70/642-V-600
- Capacity – 103 MW
- Design head – 40 m
- Flow – 285 cubic m/s
- Generator SV 1130/140-48Т:
  - Capacity – 100 MW
  - Voltage – 13.8 kV
The hydraulic engineering facilities include: embankment dam, HPP building with water gate, irrigational water inlet and step-up substation.

The reservoir of 12 billion cubic m created by the dam provides for irrigation of additional 640 thousand hectares of fertile lands in the country, and also for generation of 1.6 billion kW.h of electric power per year.

The embankment dam with a length of 4,279 m was constructed by hydraulic fill with the gravel-sandy-loamy material. The maximum height of the hydraulic-fill dam is 58 m. The spillway above the power hall has eight flights, 15 m in width, equipped with the segmental gates.

The HPP is combined with the overflow spillway; it is equipped with eight hydraulic units, total capacity 800 MW. The Kaplan turbines and umbrella-type synchronous generators, capacity 100 MW each, are installed in the HPP building.

The step-up transformers are located in the room behind the lower wall of the power hall. The 220-kV oil-filled cables serve as the transformer leads to the outdoor switchgear site. Electric power from the hydro power plant is transmitted to the city of Khaleb via two 220-kV overhead power transmission lines.

HYDROPOWER COMPLEX ON THE EUPHRATES
the largest hydropower complex in the Middle East, has been erected to solve the problem of irrigation, to generate electric power and to regulate the flow for protection of the downstream districts against flooding.
HYDRO POWER PLANT “DZHERDAP I – IRON GATES I”

Electromechanical equipment

Number of units – 6+6
Kaplan turbine PL 40/587aV-950:
Capacity – 178 MW
Design head – 27.16 m
Flow – 707 cubic m/s
Generator SV 1500/175-84:
Capacity – 171 MW
Voltage – 15.75 kV
Hydro Power Plant “Dzherdap I – Iron Gates I”

HYDRO POWER PLANT “DZHERDAP I – IRON GATES I”

is the largest on the Danube and one of the most powerful in Europe.

Originally, each power hall had six Kaplan hydraulic units, capacity 178 MW, with impeller wheel diameter of 9.5 m. Later, the Romanian hydraulic units were upgraded with the capacity increased up to 194.3 MW. In 1986-1987 Technopromexport put into operation the second expansion of «Dzherdap I – Iron Gates I» HPP - «Dzherdap II – Iron Gates II» HPP, which has eight unique bulb-type hydroelectric units.
ASWAN HYDROPOWER COMPLEX

EGYPT

2100 MW
Capacity

12 units

ASWAN HYDROPOWER COMPLEX

Egypt

NORTH-EASTERN AFRICA

Year of completion 1970

Electromechanical equipment

Number of units — 12
Radial-axial turbine RO 75/728b-V-630b:
Capacity — 180 MW
Design head — 57.5 m
Flow — 350 cubic m/s
Generator — SV 1260/235-60T:
Capacity — 175 MW
Voltage — 13.8 kV
This hydropower complex was built to solve whole complex of regional problems: prevention of flooding, power supply in Egypt and building a network of irrigation canals for agriculture.

For the project implementation, about 750 thousand tons of equipment and materials produced at more than 300 plants and industrial enterprises of the former USSR have been delivered to Egypt.

The reservoir having a useful volume of 114.2 cubic km, created by the Aswan dam, controls the Nile flow. It provided for irrigation of additional 700 thousand hectares of new lands. The area of irrigated lands of the country has increased 30 %.

The hydro power plant including twelve generators produces 8 billion kWh of electric power a year. With the HPP commissioning, the annual power production in Egypt was increased two times.

The waterfront of the hydraulic power system of 3,820 m is formed by the 111-m high embankment dam.

A number of solutions unprecedented in the world hydraulic engineering practice have been developed and tested in the embankment dam design. The dam is erected on the sandy base in the existing reservoir formed by an old Aswan dam. The dam body of 41376 million cubic m consists of the rock mass, fine-grain and coarse-grain sands and sorted stones hydraulically filled with sand. A unique grout curtain to a depth of 165 m (of which 30 to 40 m are grouted embankment) has been built in the foundation and the sand body of the 40-m thick dam. The total volume of grouted ground is 2.1 million cubic m.

The water-proof elements of the structures in combination with the water-resistant structures (central clay core, apron and vertical curtain) ensure the filtration and static stability of the dam.

A flood gate is built on the left bank in the form of a concrete overflow dam to a length of 288 m designed for the water flow of 5000 cubic m/s.

The spillover facilities have a total length of 1970 m including a power canal of 1150 m, tunnels of 282 m and a tail-water channel of 538 m. The cross-section of the water tunnels, diameter 15 m, is designed for water flow of 11,000 cubic m/s.

The water inlet being the main facility of the turbine and the discharge sections are provided with the main vertical-lift bottom gates, and also the duplicate gates and the trash racks; the water inlet has two tiers: the lower tier designed for the diversion flow during construction of the hydraulic engineering installation, and the upper operational tier (12 flights, 5 m in width).

The hydro power plant of installed capacity of 2,100 MW is provided with 12 radial-axial vertical turbines and generators, capacity 175 MW; it generates 8 billion kWh of electric power per year.

The electromechanical equipment provides delivery of the 1,500-MW electric power via two 500-kV lines to the Cairo power supply system, and the 600-MW power via eight 132-kV lines to the local power district.
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