

**SUPPLY OF 2X215 MVA GENERATOR STEP-UP  
TRANSFORMERS FOR PĻAVIŅU HPP. SUPERVISION  
OF INSTALLATION AND COMMISSIONING**

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PROJECT "PĻAVIŅU HPP PRIMARY EQUIPMENT REPLACEMENT"

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## 1 Scope of supply

This technical specification covers requirements of design, engineering, manufacturing, review, testing, transportation of two (2) new units of three-phase oil-immersed generator step-up (GSU) transformers, each with rated power 215 MVA.

The scope of supply shall include:

<b>Manufacturing at factory</b>	Contractor
<b>Test at factory</b>	Contractor
<b>Packaging for shipping</b>	Contractor
<b>Transportation to site (DDP Incoterms)</b>	Contractor
<b>DDP delivery at site</b>	Contractor
<b>Unloading on Site</b>	Employer
<b>Installation at site</b>	Employer
<b>Installation supervision</b>	Contractor
<b>Tests at site</b>	Contractor
<b>Commissioning at site</b>	Contractor
<b>Training at site</b>	Contractor
<b>Documentation</b>	Contractor
<b>Quality control</b>	Contractor
<b>Recommended spare part list for five (5) years operation</b>	Contractor
<b>Guarantees</b>	Contractor
<b>Warranty</b>	Contractor

## 2 Site location

The two (2) new GSU transformers will be installed in the Pļaviņu hydro power plant (PHPP) located close to the community of Aizkraukle, about 90km outside of Riga, the Capital of Latvia.

## 3 Transport, installation and storage

Transportation of the two (2) new GSU transformers to the Employer's Erection Bay in the vicinity of the Site in Aizkraukle and all unloading (excluding unloading at PHPP Erection bay), shall be included in the supply. The transformers shall be prepared for long term storage and storage instructions shall be provided.

During transport the two (2) new GSU transformers shall each be equipped with an impact recorder to register g-forces in x-, y- and z-directions. Maximum allowed stresses and setting of the detection limits of the impact recorder shall be agreed upon between the Contractor and the Employer (AS Latvenergo).

The two (2) new GSU transformers will be installed outdoors equally in the same place as the existing two (2) GSU transformers, which means using wheels for erection on the

existing rails. The erection and installation of the transformers are NOT included in the scope of supply under this specification.

#### **4 Legislation, standards and codes**

The GSU transformers supplied with accessories shall be designed, manufactured and tested in accordance with the latest edition of the Latvian legislation, standards and codes.

Examples of important legislation, standards and codes that shall be met are:

- Latvian Grid Code "Network Code for Electricity Sector" (refer to Attachment 2).
- EN 60076 family of standards covering power transformers and auxiliaries.
- Eco design requirements according to requirements set in Tier 2 in Commission Regulation (EU) 2019/1783.

If Latvian standards are missing all applicable and/or corresponding European EN standards and International IEC standards shall be applied. In the event of differences between this document and the relevant standard, the technical requirements in this document shall have precedence.

The Contractor is required to specify which standards the Contractor will apply for the design, manufacturing, construction, installation, testing and commission.

#### **5 Operating conditions**

##### **5.1 General**

The GSU transformers shall be designed for continuous operation at rated power and cooling water temperature 25 deg C, considering ageing rate  $V=1.0$  as per IEC 60076-7:2017 and most unfavourable service conditions according to EN 60076 family of standards, Latvian grid code and requirements stated in this section. The transformer shall be designed as regularly energised transformer (in excess of 24 times per year).

##### **5.2 Ambient temperature**

As a lower limit of ambient air temperature  $-40^{\circ}\text{C}$  shall apply outdoor.

##### **5.3 Mode of operation**

The GSU transformers shall be capable of bi-directional power flow.

##### **5.4 Network data**

Calculated short circuit currents Medium voltage side:

$$I(3) = 65,0 \text{ kA}; i_{\text{peak}} = 176,2 \text{ kA}$$

Calculated short circuit currents High voltage side:

$$I(3) = 18,5 \text{ kA}; i_{\text{peak}} = 46,3 \text{ kA}$$

On the 13.8 kV side of each of the two (2) GSU transformers two (2) equal synchronous generators, 2 x 106 MVA, are connected.

## 5.5 Geomagnetic disturbances

The Contractor shall in its tender specify the DC current capability according to IEEE C57.163-2015.

## 5.6 Other operating requirements

The GSU transformers shall be capable of withstanding the mechanical and thermal effects associated with short circuit currents in accordance with EN 60076-5 when operating on any tapping position.

The GSU transformers shall be capable of withstanding stresses during switching at 0-180° phase opposition.

Bushings, on-load tap-changers and other accessories shall be selected in such way that they can carry currents above the corresponding winding rated current of at least the same amplitude and for the same duration as the GSU transformer itself can withstand. Worst tap changer position shall be considered.

The GSU transformers neutral and its bushings as well as built in bushing current transformers shall have the same loading capability as the corresponding line terminals.

# 6 Electrical design features

## 6.1 General data

Power transformer type	Three-phase oil-immersed generator step-up (GSU) transformers
Rated power	215 MVA
Rated voltage	330± 8x1,67%/13,8 kV
Highest voltage for equipment	420/17,5 kV
Vector group	YNd11
Insulation level 420 kV	Phases: LI 1300 kV, SI 1050 kV Neutral: LI 170 kV, AC 70 kV
Insulation level 17,5 kV	Phases: LI 110 kV, AC 50 kV
Loading capability	Continuous at rated power (see also section 5.1)
Rated frequency	50 Hz

## 6.2 Air clearance

Highest voltage for equipment (kV)	Minimum free air clearance phase-earth (mm)	Minimum free air clearance phase-phase (mm)	Minimum free air clearance neutral-earth (mm)
420	3100	3600	1300
17,5	220	*	

**\* Free air clearance phase-phase for 17,5 kV shall be adapted for connection of new insulated phase busducts (IPB's). The phase-phase c/c IPB measure of existing GSU transformers is shown in attached drawing. The overall and full responsibility of establish a fully functioning interface between existing 330 kV cable and new GSU transformers HV terminals, new IPB's and new GSU transformers is on the Contractor.**

Minimum air clearances for 420 kV are based upon EN 60076-3.

Minimum air clearances for 17,5 kV are based upon EN 61936-1.

The air clearance is assumed to be measured from bushing live parts.

## 6.3 Creepage distances

The creepage distance of all insulators must not be less than 43,3 mm/kV phase-earth using phase voltage.

Phase voltage = Highest voltage for equipment  $/\sqrt{3}$ .

The requested value of creepage distance corresponds to class "Heavy pollution" in IEC/TS 60815-3.

## 6.4 Short circuit impedance

Short circuit impedance of the new GSU transformers shall be 12,5%.

The deviation between measured and guaranteed short circuit impedance shall not exceed -0% and +7,5 %.

## 6.5 Other data

### 6.5.1 Auxiliary AC voltage system

Existing auxiliary AC voltage system is a 3-phase system, 400/230 V, 50 Hz, 2 redundant AC inputs shall be considered and automatic transfer build in the cubicle shall be foreseen. For AC power supply, everything must be made in such a way that there is no need to deblock the signals after switching the automatic power supply transfer.

### 6.5.2 Auxiliary DC voltage system

Existing auxiliary DC voltage system is a DC battery system, 220 V. Two redundant DC inputs shall be considered



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Data for auxiliary contacts shall be adapted to actual loads. According to EN 62271-1 the break and make current shall be minimum 2 A at 220 V DC with a current time constant of at least 20 ms.

#### **6.5.3 Electromagnetic compatibility (EMC)**

Control equipment, cooling equipment and on-load tap-changer motor drive equipment shall fulfil the requirements set up in EN or IEC 61000 family of standards.

### **7 Mechanical design features**

#### **7.1 General**

The two (2) new transformers shall each have a total weight not more than 250 t. The transformer shall fit the size of existing installation place, considering permissible clearances. The transformer and its equipment, after installation, must not interfere with or restrict the operation of existing equipment (for example, obstruct the operation of crane).

#### **7.2 Transformer tank**

##### **7.2.1 General**

Each GSU transformer consist of one tank.

All welding shall be performed in accordance with applicable ISO standards.

Preparation grade P3 (very thorough preparation) shall apply in accordance with EN-ISO 8501-3.

##### **7.2.2 Vacuum safety**

The tank shall be designed and manufactured to withstand full internal vacuum (vacuum-proof), and all welds shall be continuous welds.

##### **7.2.3 Bottom**

The bottom of the transformer tank shall be self-supporting.

##### **7.2.4 Cover**

The tank cover shall be bolted to the transformer tank and made in a way that allows for easy opening in the future.

##### **7.2.5 Jacks**

The transformer tank shall be provided with a sufficient number of attaching plates for jacks.

In addition to the jacking plates there shall be a sufficient number of jacking positions on the tank bottom. These shall be located so that the wheels, wheel holders or bogies do not interfere with the handling of jacks.

### **7.3 Conservator**

The conservator shall be of welded design.

The position of the conservator shall consider the available space in the existing transformer pits and the required size and shape of the new oil collection pit under each transformer.

The conservator must be equipped with necessary hand holes which makes it possible to perform inspection, cleaning and future exchange of the rubber bag.

### **7.4 Valves**

#### **7.4.1 General**

The preferred type of valves to be included is butterfly valves (for the cooling system) and ball valves for other purposes.

#### **7.4.2 Sampling**

Three (3) oil sampling valves shall be provided for oil sampling at the tank bottom, half the tank height and at top level of the tank. Additionally, each 330 kV cable box shall have sampling point.

All valves shall be located at the tank bottom level. Pipe connection from the sampling levels to the valves shall be included. The valve connections shall have R ¾" male threads. Same connection shall be used for Dissolved gas analysis (DGA and gas sampling) device.

Two portable sets of oil sampling kits for oil condition test and dissolved gas analysis shall be included and delivered to the Employer maintenance organization of the Site in Aizkraukle.

#### **7.4.3 Other valves**

The gas and oil actuated relay shall be provided with shut off valves as well as a by-pass with a shut off possibility in order to facilitate relay exchange when the transformer is in service.

The conservator shall be equipped with a drain valve at the bottom.

Each cooler and each cooling pump shall be provided with shut off valves in order to facilitate cooler or pump repair/cleaning/exchange with the GSU transformer in operation. The disconnected cooler or cooling pump must not affect the operation of any other coolers or cooling pumps.

## **7.5 Gasket and seals**

All sealings must be vacuum proof to a pressure of 20 Pa (0,2 mbar) and oil tight to a pressure of 0,2 MPa.

O-rings shall be used in general.

Silicon seals are not permitted.

Gaskets must not contain asbestos.

Required service life for all sealing devices shall be at least 60 years.

## **7.6 Surface treatments**

The transformer tank and the accessories fitted to it (boxes, cubicles, motor-drives, coolers, fans, pumps, etc.) shall be surface treated and painted according to corrosivity category C4 and H (high atmospheric corrosivity with a protection durability of 15 to 25 years) as specified in EN-ISO 12944 family of standards.

To get a uniform look the accessories shall be painted with the same colour as used for the tank.

The Light grey (RAL 7035 or similar) color of painting shall be chosen with a high infrared emission degree and should not be shiny giving disturbances at thermographic measurements.

Painting system of carbon steel shall be designation C4.11 as specified in EN-ISO 12944-5.

All screws, washers and nuts shall be of acid proof steel, grade A4, in accordance with EN 10088-3 or of another from the corrosion point of view equivalent material. Screws and nuts shall be waxed in order to prevent seizing. Type of washers shall be selected in order to prevent paint cracking.

## **7.7 Boxes and cubicles**

Boxes and cubicles shall at least fulfil enclosure class IP65 for outdoor installation and IP43 for indoor installation according to EN 60529 and degree of protection Class I according to EN 61140.

Boxes and cubicles shall be easily accessible and located at service level (with reference to ground level).

All instrumentation in chapters 8.8 Monitoring equipment and 8.9 Depressurization system (to be used for protection functionality) shall be connected to separate marshalling boxes/cubicles respectively i.e. one marshalling box/cubicle for connection to protection system.

Boxes and cubicles for the on-load tap-changer drive and for the cooling equipment shall be provided with lighting, an earthed 230 V socket with a residual current circuit breaker and a heater to prevent condensation.

Boxes or cubicles containing equipment which requires extra heating to secure its function at - 40°C ambient temperature, shall be provided with heater controlled by a thermostat. Switch on and switch off temperatures of the thermostat shall be optimised with respect to a low temperature in combination with avoidance of moisture. An extra thermostat shall be provided to give an alarm before the temperature drops below the limit of safe equipment function.

Circa 8 mm wide test disconnect terminal blocks with slide and screw connection shall be provided to all boxes and cubicles. All terminal blocks shall be provided with labelling.

The number of terminal blocks is chosen so that each cable coming from outside can be connected to own terminal block.

Cables coming from outside shall be connected to one and the same side of the terminal blocks. Cables coming from inside shall be connected to the other side of the blocks.

Cables shall always enter boxes and cubicles from below.

Cable glands must be of metallic type and lead free according to RoHS guidelines.

## **7.8 Earthing**

### **7.8.1 Neutral point earthing**

A neutral bus shall be provided from the top of the 420 kV neutral bushing to the tank bottom (where terminal clamps for connection point to grounding network connectors shall be located). The neutral bus shall be insulated with properly sized insulators from the transformer tank and dimensioned to withstand maximum earth fault current and possible over voltages in the same way as the transformer.

For the connection of earthing cables by cable lugs the neutral bus lower end shall be provided with two (2) holes, diameter 14 mm, with a vertical centre distance of 40 mm.

### **7.8.2 Protective earthing**

For the protective earthing of the transformer tank two (2) earthing terminals diagonally located close to the tank bottom shall be provided. The terminals shall be welded to the tank and have a good electrical conductivity.

The earthing terminals shall be flat, and each provided with four (4) holes, diameter 14 mm, having a vertical centre distance of 40 mm and a horizontal centre distance of 50 mm.

All boxes, cubicles and all other equipment of metallic material not welded to the tank, shall have a protective earthing to the transformer tank through a visible green/yellow earthing connection.

Each cooler support shall be provided with one earthing terminal identical with the ones for the transformer tank.

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Transformer earthing shall be optimized in the way to reduce current flowing in earthing system. Current flowing in earthing system shall be less than with old transformer.

## **7.9 Marking**

### **7.9.1 General**

All plates shall be made of stainless steel, have engraved text and be attached by stainless steel screws (also inside the cabinets).

All plates shall be in Latvian language. English language can be accepted for plates belonging to accessories from sub Contractors.

Texts and designations shall comply with the documentation.

### **7.9.2 Designation plate**

In the middle, approximately at  $\frac{3}{4}$  height, of each long side of each transformer tank, a designation plate, #HP.U1 =A14 ATA10 (PTN04) respectively , #HP.U1 =A14 ATA10 (PTN05), shall be assembled.

### **7.9.3 Rating plate**

A rating plate of each GSU transformer shall be included in the supply containing information in accordance with EN 60076-1, clause 8 and the following information:

- Applicable EN- and/or IEC-standard.
- Highest voltage for equipment and insulation levels for all windings.

### **7.9.4 Diagram plate**

A transformer winding diagram plate of each GSU transformer shall be included in the supply and can be combined with the accessory plate.

### **7.9.5 Accessory plate**

An accessory plate of each GSU transformer shall be included in the supply containing information of the following accessories:

- Bushings.
- Valves and gauges.
- Thermometers and level indicators.
- Connection cubicles and boxes.
- Tank earthing terminals.

### **7.9.6 On-load tap changer plate**

An on-load tap changer plate of each GSU transformer shall be included in the supply that specifies the voltage and current ratios in all tap-changer positions.

### **7.9.7 Bushing current transformer plate and marking**

A rating plate of all bushing current transformers shall be included in the supply, containing information in accordance with EN 61869-2. The rating plate can either be placed inside the connection cubicle/box or be part of the rating plate of each GSU transformer.

The secondary terminals shall also be marked according to EN 61869-2. Primary terminals shall be clearly indicated.

#### **7.9.8 Cubicle plate**

All cubicles and boxes shall be provided with a plate showing the purpose (system description) and identification. Plates for cubicles and boxes shall be included in the supply.

#### **7.9.9 Bushing terminal marking**

Bushings shall be provided with terminal markings on the transformer tank cover adjacent to each bushing.

#### **7.9.10 Centre of gravity**

On the short and long sides of the transformer tank there shall be a durable marking of the centre of gravity.

#### **7.9.11 Designation system (RDS-PP)**

All parts, equipment shall be marked accordance with VGB RDS-PP standard and Employers equipment coding instruction.

The Contractor shall provide a comprehensive list of all applicable RDS-PP codes and their corresponding descriptions (explanations). This list must be submitted to the Employer for review and approval during the design phase. Only upon receiving explicit approval from the Employer may these codes be used in the technical documentation, including drawings, labels, and other relevant documents.

All RDS-PP designations and their explanations shall be consistent across all project documentation to ensure clarity and unambiguous identification. The Contractor is responsible for ensuring that any additional codes or modifications suggested during the design review process are promptly updated and resubmitted for final approval before their application in the detailed design.

### **7.10 Service platforms**

A permanently assembled light weight non metallic platform and ladder shall be provided for inspection of the gas and oil actuated (Buchholz) relays.

The platform and the ladder shall fulfil the requirements of ISO 14122-2, ISO 14122-3, ISO 14122-4 and any national requirements stated by Latvian Authorities.

The flooring surface of the platform shall be designed for improving the grip of footwear (slip protection). The preferred flooring surface shall be of lattice type and raised borders.

The ladder shall be provided with protections against falling. Heating points in ladders, railing and service platforms are not acceptable.

### **7.11 Inspection**

Service platforms and other equipment on the transformer should be positioned to allow thermographic inspection of the transformer tank cover and near the bushings. It shall be possible to climb to the top of the tank while transformer is energised and under load.

### **7.12 Wheels and wheel holders/bogies**

Wheels and necessary wheel holders or bogies shall be included in the supply and adapted for use with the existing rails.

## **8 Other design features**

### **8.1 Core design**

For optimising of the Employers costs for reactive power paid to the grid operator it is preferable that each transformer consumes from the HV grid around 2 MVAR at no load condition.

### **8.2 Winding design**

All winding wires shall be made of copper and equipped with a high temperature varnish layer. The varnish layer shall be designed for hot spot temperatures according to IEC 60076-7.

The transformer shall be designed in such a way that copper sulphide deposition will be prevented.

### **8.3 Oil and oil system**

#### **8.3.1 Oil quality**

The necessary quantity of mineral oil of naphthenic base shall be included in the supply (for transformer oil tank, conservator and cable connection boxes). Additionally, 8 m<sup>3</sup> per each transformer (2 x 8 m<sup>3</sup>) shall be delivered for filling into cooling system and provision of operational reserve to the Employer.

The mineral oil shall be new and unused and must fulfil the requirements for inhibited oil in accordance with EN-IEC 60296 and contain 0,3-0,4% of an oxidation inhibitor of type DBPC (Nynas Nytro or Shell Diala)

The oil must fulfil lowest cold start energizing temperature (LCSET) of -30 °C.

Kinematic viscosity of oil at -30°C must not be higher than 800 mm<sup>2</sup>/s.

No pour point depressants and no gas absorption additives shall be added to the oil and the oil must not contain any PCB or DBDS.

Before any oil filling control samples shall be taken and tested in the Employer's own laboratory. The test result from sampling(s) must fulfil requirements in IEC 60296 before filling is allowed. Vacuum and degassing are necessary due filling.

### 8.3.2 Oil system

The main conservator shall be provided with a rubber bag to prevent humidity and air access of the oil.

The rubber bag shall be air filled and have same temperature capability as the transformer and must have chemical compatibility to the oil.

After oil filling the leakage of air into the transformer must not exceed 0.3% (by volume).

### 8.3.3 Dehydrating breather

The dehydrating breathers of transformer tank and OLTC shall be of maintenance free design and located at service level.

### 8.3.4 Overpressure protection devices

Transformer shall be equipped with necessary oil overpressure devices. Devices shall not allow pressure rise in transformer tank. Devices shall be equipped with signalling contacts that change state when overpressure device operates. There shall be possibility to test singling contacts without operating protection device.

Overpressure devices shall be installed and equipped with piping that directs oil to pick-up points on floor not allowing to oil spread in big area.

## 8.4 Bushings

### 8.4.1 General

HV cable connection boxes with connections shall be included into scope of supply.

HV bushings shall be oil-oil type and LV bushings shall be of the oil-air type.

The bushings and their accessories shall be capable of withstanding the same overloads and overcurrents as the transformers.

The bushings shall be of a single piece Resin impregnated paper (RIP) type, that is, the hollow insulators shall not be made of linked hoods.

330 kV bushings shall be designed for HV cable (type of cable AL XLPE, 630 mm<sup>2</sup>) connection. HV cable boxes shall be equipped with Bucholz relays and over pressure protection devices with output signal contacts wired to transformer protections.

Connection boxes and connection points shall have the same design and height. Existing cable end terminations on transformer #HP.U1 =A14 ATA10 (PTN04) has to be kept. Cable terminations on transformer #HP.U1 =A15 ATA10 (PTN05) will be built by others.

Contractor shall deliver HV-cable pot heads A, B, C with oil-oil bushings and all necessary auxiliaries (including link to cable end termination).

13,8 kV bushings shall be located and constructed in such a way that they could be connected to the new busbars. It is necessary to keep existing dimensions between phases. Interface to the busbars is to be coordinated with the busbar suppliers

Insulators on low voltage level, which will be operating in the busbar enclosure shall be porcelain type.



#### **8.4.2 Measuring taps**

Bushings for phases and neutral shall be equipped with capacitive measuring taps which are connected to a separate connection box easily accessible at service level. The measuring taps shall normally be short circuited.

#### **8.4.3 Terminals**

Bushing terminals for 420 kV and 17,5 kV phases and neutral shall primarily be provided with flat terminals in vertical position and adapted to conditions according to section 5 and 6 in this technical specification.

Flat terminals for 420 kV phases and 420 kV neutral shall be made of copper or a copper alloy and shall be tin coated to a layer thickness of at least 50  $\mu\text{m}$ .

Flat terminals for 17,5 kV phases shall be made of aluminium or an aluminium alloy of minimum hardness HB 75 and shall not be surface treated. Flat terminals for 17,5 kV phases shall be adapted for connection of new IPBs and all material needed for connection of new IPB:s shall be included in the supply. The overall responsibility of establishing a fully functioning IPB interface is on the transformer Contractor.

### **8.5 Bushing and neutral current transformers**

#### **8.5.1 General**

The current transformers shall fulfil the requirements in EN 61869-1 and EN 61869-2.

The current transformers shall be capable of withstanding a rated continuous thermal current of at least 1.2 times rated current of the power transformer.

The bushing current transformers shall be mounted with P2 closest to the transformer.

The cores shall be provided with a common test conductor with a square-section area of 35 mm<sup>2</sup> Cu, by means of which current transformer testing can be carried out without magnetizing and loading of the power transformer.

The test conductor terminal marking, M, shall correspond to P1. The test conductor shall be earthed at the end corresponding to P2.

#### **8.5.2 Phase bushing current transformers**

The phase bushing current transformers shall be designed with:

Supplier shall delivery current transformers with 0.5 class for transformer monitoring system if necessary as well as for OLTC measurements.

Each core shall have its own secondary winding which shall be electrically completely separated from the other windings.

### 8.5.3 High voltage neutral bushing current transformer

Two bushing type current transformer (for each transformer) for protection with a 300/1 A transformer ratio, 30VA, 5P20 shall be included.

## 8.6 On-load tap changer (OLTC)

### 8.6.1 General

Change of ratio in operation shall be made by a high speed on-load tap changer (OLTC) for remote and local operation. The OLTC shall fulfil the requirements in EN 60214-1 and IEC/IEEE 60214-2.

The OLTC shall be rated for at least the same current as the transformer winding.

The number of tap positions shall be in total 17 steps according to  $\pm 8 \times 1,67\%$ .

Diverter switch shall be of type vacuum switching technology.

The oil in the diverter switch compartment shall be totally separated from the oil in the transformer tank. The allowable brands of OLTC are Hitachi, MR and Siemens.

### 8.6.2 Motor drive

The motor operating mechanism shall be constructed for local and remote motor operation.

The drive motor shall be designed for 400 V AC, 3-phase, 50 Hz power supply. The motor drive control and operation shall be designed for 220 V DC supply.

The drive motor shall be protected against overload by a protective switch with an auxiliary contact which is closed when the switch is open.

It shall also be possible to operate the OLTC by hand using a crank which shall be included in the supply.

Contacts for raise and lower shall be electrically and mechanically interlocked.

Circuits for motor, control, position indication and heating shall be electrically completely (galvanically) separated.

The tap positions shall be numbered from one (1) and upwards. Operation towards a higher tapping position shall correspond to a reduced ratio implying a higher voltage on the secondary side of the transformer.

OLTC position shall be shown in the drive mechanism and readable from the outside. Number of operations shall be recorded by a six-digit mechanical counter, also readable from the outside, and without possibility to reset the counter.

OLTC position shall also be indicated by an analogue potentiometer transmitter with as many positions (N) as the OLTC and including N-1 sub-resistors. Each resistor shall be of about 10 or 50  $\Omega$  with an individual spread of maximum 0.5%. For remote indication of the OLTC position, a measuring amplifier (transducer) 4 - 20 mA shall be provided.

### 8.6.3 Other functionality

A started cycle of operation shall be completed even if the operation pulse length is shorter than the time required for one step.

When an overcurrent is passing through the tap-changer the drive motor shall stop and the operation shall be completed when the overcurrent has ceased.

End positions shall be equipped with contacts opening both motor drive and control circuits for relevant operating direction.

### 8.6.4 OLTC controllers

On load tap changer control functionality for tap changer control of new transformers #HP.U1 A14 ATA10 (PTN04) and #HP.U1 A15 ATA10 (PTN05) main transformers shall be supplied as separate IED units (one IED per main transformer). Full operational control and alarm/indications shall be possible and presented both in the station control system and locally in electronic touch panel or IED devices own user interface. All measurements and signals shall be exchanged with station control system for real-time and historical data functionality. The OLTC shall have a mode for Black start functionality. The scope of supply only includes the hardware (i.e. supply of OLTC IEDs and local user interface) and installation supervision.

The tap changer control functionality shall have the following features:

Operation location:	Local / Remote
Operation:	Automatic / Manual
Setting area:	90–110 % av Un (13,8 kV)
Resolution:	≤ 0,5 % of Un (13,8 kV)
Max deviation (dead band): (13,8 kV)	+ - 0,5 % to + - 3 % of Un, resolution ≤ 0,1 % of Un
Value recording:	U, I, TC position (7 days) 1/hour
Event recording:	Regulation Mode Change, Alarms, (with U, I, TC pos.)
Measured Voltage:	13,8kV/100V L1-L3
Measured Current:	1A
Output Relays:	220V AC (5 A)
Inputs for setpoint change:	4 pre-programmed setpoints
Indications:	U, I, TC pos, Regulation Mode
Serial Connection to DCS:	OPC UA, IEC 870-5-104, Modbus TCP
Time characteristic:	definite and inverse
Operating time (definite):	15, 30, 60, 90, 120 s
Range for under voltage block:	70–110 % x Un (13,8 kV)

Range for under voltage block: 0%-  $U_n$  (13,8 kV) (for Black start mode)

Range for over voltage block: 90–130 % x  $U_n$  (13,8 kV)

Alarm for voltage below low voltage limit (with activated TC functionality)

Alarm for voltage above high voltage limit (with activated TC functionality)

Alarm for failed/non-execution of order

Alarm from watch dog (self-monitoring)

Alarm from loss of voltage (DC/DC) supply

## **8.7 Cooling equipment**

### **8.7.1 General**

The type of cooling shall be OFWF. The scope of supply shall include complete design for the transformer cooling system, including routing and length of cooling water pipes. The detailed design of the cooling system is included in the scope of supply.

The existing cooling system is with forced oil and water circulation. Cooling water is supplied from the river through water filters (8 mm) on elevation 32,64 m and its pressure is within the range of 3,0 bar to 2,4 bar. The supplied cooling water max  $t$  is 25 °C. The Supplier is obliged to carry out river water analyses to choose correct equipment in order to determine amount and properties of polluting particles.

The scope of supply shall include the supply of 2 x 100% new oil/water coolers, 2 x 100% oil pumps, 1 x 100% automatic self cleaning filter skid with isolation valves and bypass valve, accessories and control cubicle, 2 pcs cooling water flow control valves with automatic control on water side to minimise water consumption when transformer load is low, interfacing oil pipes/flanges on the transformer (horizontal stainless steel pipes 1m above the ground level) and the cooling automation control system (including FAT, site tests and site commissioning etc.). The cooling automation control system shall be supplied in a new cubicle (1 for each transformer) to be installed in transformer cooling room and shall have interfaces to the existing station control system. All measurement signals shall be connected to cooler automation system. Cooling automation system shall provide all measurement and status data about related transformer and subsystems to station control system via OPC UA or other suitable communication protocol.

Parameters that shall be monitoring:

- Transformer oil temperatures (top, bottom)
- Transformer core and windings temperatures (hot spot temperature according to IEC 60076-7);
- Transformer direct winding temperature measurement using optical fibre (along the length of the winding)
- Oil level

- Ambient temperature and humidity.
- Cooling system monitoring:
  - Cooling control
  - Cooler starts & and cooling efficiency
  - Oil and water (in and out) temperatures (sensors shall be located in way that it is possible to clean cooler without dismantle of any sensors).

The cooling equipment shall be divided in two groups (2 x 100% redundant), each with separate coolers, pumps and instruments etc. with sufficient capacity for the performance of cooling under most difficult ambient conditions. Each cooling group must have the same cooling capacity. The groups shall be electrically separate, have its own protection, measurement and control and be supplied through separate cables with separated cable routing. The Contractor shall in the design of coolers consider the cooler locations at site and guarantee that the necessary cooling will be ensured. The design shall also consider the existing configuration with gravity fed cooling water supply that will be kept. The design shall be based on the requirements and conditions in section 5 and 6 in this technical specification. In general, the existing dedicated cooling system rooms shall be reused for the installation of main TN cooling equipment.

Pump motors shall be designed for a 400 V, 3-phase, 50 Hz power supply.

The motor operating voltage shall be 230 V, 50 Hz power supply and control voltage shall be 220 V DC.

#### 8.7.2 **OF.. type of cooling**

Oil pumps, oil tubes/pipes and other components having circulating oil must withstand an internal overpressure of 0.5 MPa(e) without any leakage of oil having a temperature of 90°C.

#### 8.7.3 **..WF type of cooling**

Water cooler, tubes/pipes etc. (cooling type ..WF) shall withstand an internal overpressure of 0.8 MPa(e). The design of the coolers shall consider minimisation of shell or algae formation

Water coolers shall be of double wall/tube design with leakage detection. Minimal wall thickness of the tube is to be 1mm and shall allow frequent cleaning. Material of the tube shall be either CuNiFe or 316 stainless steel.

#### 8.7.4 **Cooler control**

Two (2) top oil temperature sensor and two (2) mutually independent winding temperature sensors shall be provided for control and supervision of the cooling system. The contacts for the hottest winding and top oil shall be connected in parallel.

### 8.7.5 Automatic self cleaning filters

Transformer cooling system shall be equipped with self-cleaning water filter equipment. Equipment shall be located in the cooling room. Technical requirements for equipment are following:

- Automatic self-cleaning filter purification step shall be no less than 1 mm.
- Automatic self-cleaning filter equipment shall be calculated and designed for water pressure 6 bar.
- Automatic self-cleaning filter equipment housing, pipe lines shall be made from stainless steel.
- Automatic self-cleaning filter equipment shall be sufficient capacity and shall be operated without pumps. Maintenance for automatic filter shall not be required more often than once in year.
- There shall be same dimension water bypass pipe to supply water during maintenance of automatic filter.
- Automatic self-cleaning filter equipment shall be equipped with differential pressure manometers for alarming if pressure drop to exceed allowed level.
- Signals from automatic self-cleaning filter equipment shall be wired to cooling system control, alarm signals cubicle and monitoring system.

## 8.8 Monitoring equipment

### 8.8.1 Gas and oil actuated relay

On the pipe connecting the transformer tank and the conservator a gas and oil actuated relay (Buchholz relay) shall be provided.

The gas and oil actuated relay shall be provided with two (2) galvanically separated sets of contacts:

- Contacts that close in the event of slow gas formation to be used for alarm.
- Contacts that close in the event of heavy gas formation, heavy oil flow and low oil level to be used for tripping.

Gas sampling and functional testing shall be possible to carry out when the transformer is in service. Gas sampling device shall be located in ground level.

Buchholz relays shall be provided for each cable box and wired to protections.

### 8.8.2 OLTC relay

The diverter switch oil compartment shall be provided with an overpressure relay (alternatively an oil-flow relay) equipped with two (2) adjustable contact closings when reaching a pressure (alternatively an oil flow) as specified by the Contractor.

It shall be possible to perform a function test of the overpressure relay (oil flow relay) without disassembly.

### 8.8.3 Oil level indicator

Transformer conservator and OLTC conservator shall be equipped with separate dial oil level indicators with normally open contacts for high and low oil level.

The oil level indicators shall be located in the way that it is possible to see reading from ground level. Drip protection to prevent water from dripping into oil level indicators.

### 8.8.4 Temperature gauges (thermometers)

The GSU transformers shall be provided with:

- Two (2) temperature gauges for the top oil temperature.
- One (1) temperature gauge in each winding showing the true winding hot spot temperature.

In addition to thermometer pockets for the above gauges there shall be one extra thermometer pocket.

The temperature gauges shall at least have four (4) independently adjustable contacts closing when the temperature reaches the adjusted value.

All temperature gauges shall be provided with Pt100 resistors for remote temperature indication.

### 8.8.5 Cooling equipment gauges

For cooling type OF.. oil flow gauges at too low oil flow shall be provided that includes closing of contacts. Contact closing shall occur also in case of wrong oil flow direction.

For cooling type ..WF the following is required for each cooler:

- Oil flow gauge and meter with one contact closing for a flow above and below settings specified by the Contractor.
- Electromagnetic water flow meter with display and 4-20 mA output signal connected to monitoring equipment control. Alarm flow above and below settings specified by the Contractor.
- All contacts are intended for signalling/alarms/trips.
- For each cooler Pt100 temperature transmitter shall be provided for oil in each cooler, oil out of each cooler, water in each cooler and water out of each cooler.
- Coolers shall be equipped with necessary instrumentation for leakage detection inside of cooler.

### 8.8.6 Online monitoring system

The supply shall include installation of an on-line power transformer monitoring system for each unit of the two (2) new GSU transformers. The transformer monitoring system shall be in accordance with IEEE C57.143 and IEC 60076.

OLTC monitoring shall be capable of monitoring these parameters:

- OLTC tap position and run time and count of each tap
- Load current
- OLTC oil temperatures
- Maintenance and replacement intervals, contact wear
- Online vibroacoustic measurement and torque monitoring of the on-load tapchanger (VAM)

Requirements for OLTC monitoring system:

2.	Digital communication/ protocols	Ethernet (RJ45) Modbus TCP
3.	Supply voltage	AC: 100 – 240 V 50 Hz DC: 110 – 220 V (DC preferred)
4.	IP class	At least IP 56
5.	Certification	Calibration certificate, Proof of verification, CE (Conformité Européenne) marking
6.	Documentation	Installation and operating instructions, to the extent that the Customer can independently install and adjust the equipment.

The measured values must be presented in a clear and understandable way and include trend analysis.

The monitoring system must meet EMC compliance according EN 61000 family of standards.

The monitoring system communication shall be based on standardized and established open communication protocols in accordance with IEC standards.

The monitoring system shall be provided with all necessary accessories, software and documentation needed for operation of the system.

Monitoring system shall be provided with fibre optic and electrical connection interface, Ethernet. Monitoring system shall be connected to station control system.

Monitoring system shall be calibrated by a qualified professional with relevant expertise and experience.

Note! All configuration works and required software on existing workstations to allow monitoring and long term storage of monitoring data is included into scope of works under this specification.

## 8.9 Depressurization system

The supply shall include a complete fast acting depressurization system with N2 injection installed for each unit of the two (2) new GSU transformers including all components, piping as well as wiring, provided that depressurization system control cubicle is located



in the same room where transformer is installed. The material for piping shall be stainless steel.

The system shall be able to depressurize the transformer tank OLTC and 3 cable connection boxes in a safe way to avoid explosion and fire caused by internal short-circuits and arcing.

The supply shall include both components for collecting the depressurized oil and gases and components for channel the gas to a safe remote area.

Signals shall be connected to transformer protection and station control system.

Depressurization systems manufacturers commissioning report shall be submitted to Employer before energization of transformer.

### **8.10 Cables**

Scope of supply shall at least include all cables between instruments on the transformer and transformer control cubicle(s).

All cables must be of halogen-free design and fitted with shield or wire-armouring.

Cable sheath/screen and protective earthing conductor shall be earthed in both ends of the power cables. Control cables for control signals and sensor signals should be in a screened cable, the screen should be open in the equipment end side and earthed in the main control system cubicle.

All cables and cable cores/wires shall be provided with individual markings at both ends for the identification in the circuit diagram.

All cables outside boxes and cubicles shall be provided with markings made of stainless steel with engraved text.

All cables installed outdoors shall be installed inside protective cable channel with cover (specified for outdoor installation).

For any new external cables, individual identification tags/labels shall be included with individual cable number for each cable. Cable list shall be submitted with information of cable type, cross-section area, length and installation date. Cables shall be marked according to Employer's rules. Cable markings shall be approved by Customer.

Cable identification tags/labels shall be resistant to environmental impact and be of Partex system type or similar indoors. Outdoor cable identification tags/labels shall be of engraved metal type. Cable identification tags/labels shall be attached to both ends of the cable line as well as in areas where the cables are crossing the building walls and slabs (on both sides of the obstacle). Cable identification tags/labels for underground cables shall be placed on both sides of cable tunnels, cable channels etc. In straight cable line sections identification tags/labels shall be installed on every 50 m.

For cable lines above 1kV it is forbidden to install cable identification tags/labels on the cable ends and sleeves.

All wires including spare shall be marked in both cable ends.

### **8.11 Sound levels**

The maximum allowable sound power level,  $L_{WA}$ , is 80 dB(A). A positive tolerance of +0 dB(A) shall be valid. The measurement shall be carried out according to EN 60076-10.

The maximum sound power level,  $L_{WA}$ , shall apply both with and without cooling equipment in operation.

### **8.12 Spare parts**

Spare parts shall be interchangeable with and of the same materials and quality as the original parts of the equipment. Spare parts shall be treated and packed as required to preserve them against deterioration in storage. Each part shall be clearly marked for easy identification according to the spare parts list.

In the tender, the Contractor shall submit an itemized list of 'Recommended Spare Parts', including price. In preparing this list consideration shall be given to the time required for obtaining spare parts in case of failure of a critical component.

## **9 Design review**

The following design review shall be conducted by the Contractor in accordance with guidelines in Cigré TB 209, Cigré TB 529, EN 60076-2 and EN 60076-5:

- Verify that the design complies with the technical requirements in the Technical Specification.
- Thermal design review by calculating rise of top oil temperature, rise of average oil temperature, rise of average winding temperature, rise of hotspot temperature and its position, determination of the hotspot factor to be used at the temperature rise test (by application of EN 60076-2 procedure).
- Mechanical design review by calculations of forces and stresses in relation to allowed criteria (EN 60076-5, Annex A is a benchmark).
- The Contractor shall specify the maximum amplitude of the inrush current in the most unfavourable phase position and at the highest overexcitation conditions.
- The Contractor shall specify a solution for the sealing system, including a gasket and seal specification.

A meeting protocol must be produced by the Contractor which includes the given information and outcome from the meeting.

The design review must be performed before manufacturing starts.

Contractor shall review existing transformer protection settings and make necessary modifications

## 10 Inspection and test plan (ITP)

The Contractor shall for each GSU transformer establish a main inspection and test plan (ITP) containing all the inspections and tests which shall be performed during the manufacturing, factory acceptance tests (FAT), final assembly and commissioning.

## 11 Factory acceptance tests (FAT)

### 11.1 Test program

Notice of FAT date together with a final test program with clearly developed each stage of manufacture, testing and preparation must be submitted to the Employer at least two weeks before commencement of the FAT tests. The Employer reserves the rights to attend up to four representatives the manufacturing plant at his own expense in order to participate at the factory tests of transformers. The Contractor provides for the access of Employer's personnel and safety during the tests.

The transformers shall be subjected to tests in accordance with IEC 60076.

### 11.2 Tests on new GSU transformers

The following tests shall be performed on each unit of the two (2) new GSU transformers:

- Measurement of winding resistance according to EN 60076-1.
- Measurement of voltage ratio and check of phase displacement according to EN 60076-1.
- Measurement of short-circuit impedance and load loss according to EN 60076-1.
- Measurement of no-load loss and no-load current according to EN 60076-1.
- Measurement of zero-sequence impedances according to EN 60076-1.
- Applied withstand voltage test according to EN 60076-3.
- Induced voltage withstand test (IVW) according to EN 60076-3. Performed only when applicable and recommended by Contractor on highest voltage of equipment 17,5 kV.
- Induced voltage withstand test with PD-measurement (IVPD) according to EN 60076-3. Only applicable on highest voltage of equipment 420 kV. The measurements must meet:
  - PD detection method shall be of type broad band measurement.
  - PD guarantee level  $\leq 100$  pC shall apply when  $U = 1.2 \times U_r / \sqrt{3}$ .
  - PD guarantee level  $\leq 250$  pC shall apply when  $U = 1.58 \times U_r / \sqrt{3}$ .
  - For PD-levels  $> 100$  pC a written explanation must be presented and approved by the Employer.
- Lightning impulse tests on all phase terminals and neutral terminals according to EN 60076-3.
- Chopped wave lightning impulse tests according to EN 60076-3. Only applicable on highest voltage of equipment 420 kV.

- Switching impulse tests on all phase terminals according to EN 60076-3. Only applicable on highest voltage of equipment 420 kV.
- FRA fingerprint measurement according to EN 60076-1.
- Leak testing with pressure according to EN 60076-1.
- Check of core and frame insulation according to EN 60076-1. The following insulation resistances shall be measured:
  - Core to tank.
  - Core to yoke clamps.
  - Yoke clamps to tank.
- Determination of capacitances and values of tan delta, windings to earth and between windings.
- Measurement of DC insulation resistance between each winding to earth and between windings.
- Temperature rise test according to EN 60076-2.
- Measurement of sound levels according to EN 60076-10.
- Tests and inspections on accessories. Each complete control equipment shall be voltage tested with 2 kV 50 Hz for 1 min. Motors for the on-load tap-changer motor drive shall be subjected to a test with at least 1.5 kV 50 Hz for 1 min.

### **11.3 Tests on bushing current transformers**

The following tests on bushing current transformers shall be performed on each unit of the two (2) new GSU transformers:

- Check of ratio and polarity of all built in current transformers.
- Saturation measurement with determination of knee-point voltage.
- A power frequency test shall be carried out on the test conductor at 3 kVrms, the windings and other current transformer parts being earthed.

Test certificates of all bushing current transformers shall be provided.

### **11.4 Tests on on-load tap changer**

Operation tests according to EN 60076-1 shall be performed on each unit of the two (2) new GSU transformers.

### **11.5 Painting inspection**

A painting inspection certificate shall accompany each unit of the two (2) new GSU transformers.

### **11.6 FAT report**

The FAT report must include results from all tests compiled in a document together with the test program as well as (potential) non-conformance reports.

Measured values shown in test reports shall be according to international (SI) System of Units.

## 12 Site tests

Minimum the following site test shall be carried out on each unit of the two (2) new GSU transformers before taking the transformers in operation (all tests shall be performed by certified laboratory):

- Oil quality test.
- Dissolved gas analysis.
- Frequency dielectric spectroscopy fingerprint.
- Sweep frequency response analysis (FRA).
- Winding insulation resistance and polarisation index measurement.
- Core insulation resistance measurement.
- Winding resistance measurement (if bushings has been removed during transport).
- Bushing current transformer ratio and no-load current characteristic check (if current transformers have been removed during transport).
- 230 V single phase no-load current measurement.
- Operational tests on all accessories (this tests shall be performed by commissioning engineer).

## 13 Documentation

All documentation shall be in English language. Operation and maintenance manuals/instructions and Oil safety data sheets shall be provided both in English language and Latvian language.

### 13.1 Documentation for approval

The following documents shall be provided for each unit of the two (2) new GSU transformers:

One (1) month after Contract signing	For approval by Employer: <ul style="list-style-type: none"><li>• PDF copy of updated tender outline drawings including location of bushings, conservator, coolers, cooler pumps, on-load tap changer, jacking positions and boxes/cubicles/motor drives.</li><li>• PDF copy of manufacturing and testing time schedule.</li><li>• Design for transformer rail system.</li><li>• Principal design and design input for transformer cooling system.</li></ul>
Three (3) month after Contract signing	For approval by Employer: <ul style="list-style-type: none"><li>• Details of bushing interfaces</li></ul>

	<ul style="list-style-type: none"> <li>• PDF copy of binding outline drawings including accessories and accessory list.</li> <li>• PDF copy of ITP.</li> <li>• PDF copy of transformer circuit diagrams, oil circuit diagrams, cooler circuit diagrams, control equipment circuit diagrams, layouts/dimension and overview drawings of boxes/cubicles/motor drives, apparatus lists, list of plates texts and drawings of plates.</li> </ul>
One (1) month before FAT	For approval by Employer: <ul style="list-style-type: none"> <li>• PDF copy of complete final documentation.</li> <li>• PDF copy of FAT program.</li> </ul>
At the delivery	Submitted to the Employer: <ul style="list-style-type: none"> <li>• One (1) sets of the approved final documentation in paper and inserted in binders.</li> <li>• PDF copy of the approved final documentation.</li> <li>• Approved final documentation on USB.</li> </ul>

Documents for approval shall be supplied at agreed common online portal or by electronic mail.

Within ten (10) working days after receipt of the Technical Design, the Employer shall submit to the Contractor either comments and/or corrections on the Technical Design, or Approval. The Contractor must provide an answer and/or make the corrections indicated by the Employer in the Technical Design within five (5) working days, otherwise the Contractor must submit a reasonable refusal to the Employer within five (5) working days.

### 13.2 Final (As Built) documentation

The final documentation shall include detailed information and drawings for each unit of the two (2) new GSU transformers. The final documentation shall at least include:

- First sheet with Employer's and Contractor's reference numbers.
- Conclusive data sheet.
- Curve showing apparent power in relation to cooling water temperature at limitation of hot spot temperature to 98°C.
- V/HZ characteristic.
- Layouts/Dimensions, outline drawing with accessories and belonging accessory list for all supplied equipment.
- construction drawings of core and windings.
- Bushings.
- Bushing current transformers.
- On load tap changer with motor drive.
- Cooling equipment.
- Oil circuit diagram.
- Supervisory equipment and other accessories.

- Circuit diagrams with equipment and apparatus list.
- Boxes and cubicles (including circuit diagrams, equipment and apparatus list, SLDs, wiring diagrams and wire core tables).
- Transport, erection and assembly drawings.
- Product data sheet of oil.
- Oil safety data sheet.
- Gasket and sealing solutions.
- Product and safety information for all included chemical products.
- Design review report.
- Test reports (protocols, results, certificates).
- Instruction for touch-up painting.
- Operation and maintenance manual/instructions.
- Trouble-shooting instructions.
- Photographs of the active part and complete transformer.

In each section there shall be a summary of included drawings (with information of latest revision) and also the main data of included components.

A summary of all included components (list of apparatuses / equipment list) such as thermometers, on load tap changer, motor drive, pumps, fans etc. shall be provided. Type designations, ratings and a clear identification shall also be provided.

Location of bushings, bushing current transformers and on-load tap-changers shall be stated (serial No. and phase).

In submitted catalogues and pamphlets the actual component shall be legibly marked.

For programmable equipment (transducers, programmable instruments etc.), necessary software, manuals, cables, etc. shall be provided.

Operation and maintenance manuals/instructions and Oil safety data sheets shall be provided both in English language and Latvian language.

Approved final documentation shall be supplied in PDF/A format. In addition, all drawings, diagrams, layouts, lists etc. shall also be supplied in editable AUTOCAD format. For lists, AUTOCAD format could be changed to Excel format. AUTOCAD drawings shall be delivered as individual files and shall be submitted with the format dwg.

The PDF file of the final documentation shall be created in a similar design as the paper file itself (all documentation in one file). From the table of contents, it shall be possible to move to selected section of the final documentation.

### **13.3 Maintenance manuals**

The Contractor shall provide a schedule of components, which require periodic maintenance or replacement, including the frequency of these measures. This schedule shall include estimates of maintenance man-hours and cost of components. The

Contractor shall also identify maintenance operations, which might require plant/equipment shutdowns, and determine and present length of such required shutdowns.

The Contractor shall provide detailed maintenance procedures for each system component as part of a dedicated Maintenance Manual. This document must be separate from any technical specification and include:

- **Component Identification:** Clear identification of each component or subsystem requiring maintenance.
- For each maintenance task, the approximate duration and man-hours must be indicated.
- **Step-by-Step Maintenance Instructions:** Comprehensive, step-by-step instructions for performing each maintenance task. This should include pre-maintenance checks, detailed execution steps, and post-maintenance validation.
- **Safety Protocols:** Specific safety precautions that must be observed during maintenance, including personal protective equipment (PPE) requirements, lockout/tagout (LOTO) procedures, and any necessary isolation of electrical or mechanical systems.
- **Duration:** For each maintenance task, the approximate duration and man-hours must be indicated.
- **Tools and Equipment:** A detailed list of special tools, instruments, or equipment needed for each maintenance task. This should include any calibration tools required for post-maintenance checks.
- **Test and Calibration:** Procedures for testing, calibration, or adjustment of components after maintenance to ensure continued operational efficiency and safety.
- **Hazard Warnings:** Clear identification of any potential hazards (e.g., electrical, chemical, thermal) that may be encountered during maintenance and specific mitigation measures.

All maintenance tasks and procedures shall be provided in a dedicated Maintenance Manual as a standalone document. This manual should:

- Be written in a clear and concise manner to ensure accessibility for maintenance personnel with varying levels of expertise.
- Be available in both digital and hard copy formats.



- Include high-quality diagrams, illustrations, and photos where applicable to aid in the identification of components and understanding of procedures.
- Be structured in such a way that it can easily be updated with any changes or revisions, ensuring it remains current throughout the lifespan of the system.

Maintenance Schedule Integration: Each maintenance procedure should be cross referenced with the maintenance schedule outlined in the overall service plan, ensuring that personnel are able to link specific tasks with the recommended maintenance intervals.

Operating instructions must include information on required measurements to be performed during operation, procedures for oil quality and gas-in-oil (DGA) analyses, including acceptable limit values, and detailed descriptions of the measurement methods and evaluation criteria.

Manufacturers' Guidelines: The Maintenance Manual shall include, or refer to, all applicable manufacturers' guidelines and recommendations for maintenance tasks on critical components.

## **14 Training**

The Contractor shall provide training to the Employer's personnel (up to 6 persons). The training shall cover both theoretical and practical training. Overall amount of training hours shall be not less than 12 hours for transformer equipment and additionally not less than 24 hours for optional monitoring systems (Option 1 and 2). Training language shall be English with Latvian translation. Training shall be provided before or during commissioning of first unit. Handouts for training material (in Latvian and English) shall be provided before training starts.

## **15 Organization of works at site**

To get the access to the sites the Contractor shall submit a complete list of employees for issuing the pass cards in accordance with Latvenergo AS regulations of pass regime (NOP020). For commencing work the Contractor shall have the employees instructed in accordance with K233 "The procedure of performance of work carried out by the contractors at the generation facilities"

## **16 Options**

Options can be joined into one or several equipment.

### **16.1 Option 1: On-line dissolved gas analysis (DGA) monitoring system**

The supply of option 1 shall include an on-line dissolved gas analysis (DGA) monitoring system based on spectroscopy and installed for each unit of the two (2) new GSU transformers. The monitoring system shall be capable of individual analysis of multiple gases and moisture in the transformer oil and be prepared for connection to a local existing

workstation common for the two (2) individual transformers. Requirements for monitoring system:

No	Technical parameters	Requirement
1.	Measurement technology	Gas-free self-consumption system (no losses)
2.	Equipment calibration	Self-calibrating system
3.	Frequency of measurement	≤ 2h
4.	Device measurement resource	No consumables or components requiring replacement on a fixed schedule.
5.	Number of dissolved gases to be analysed	≥ 7 pcs
5.1.	Hydrogen (H <sub>2</sub> )	Unit of measurement: ppm Measurement accuracy: ≤ ± 10 % Measuring range: 0 – 3000 ppm
5.2.	Methane (CH <sub>4</sub> )	Unit of measurement: ppm Measurement accuracy: ≤ ± 5 % Measuring range: 0 – 3000 ppm
5.3.	Acetylene (C <sub>2</sub> H <sub>2</sub> )	Unit of measurement: ppm Measurement accuracy: ≤ ± 5 % Measuring range: 0 – 3000 ppm
5.4.	Ethane (C <sub>2</sub> H <sub>6</sub> )	Unit of measurement: ppm Measurement accuracy: ≤ ± 5 % Measuring range: 0 – 5000 ppm
5.5.	Ethylene (C <sub>2</sub> H <sub>4</sub> )	Unit of measurement: ppm Measurement accuracy: ≤ ± 5 % Measuring range: 0 – 5000 ppm
5.6.	Oxygen (O <sub>2</sub> ) (If offered)	Unit of measurement: ppm Measurement accuracy: ≤ ± 10% Measuring range: 0 – 3000 ppm
5.7.	Nitrogen (N <sub>2</sub> ) (If offered)	Unit of measurement: ppm Measurement accuracy: ≤ ± 15% Measuring range: 0 – 3000 ppm
5.8.	Carbon monoxide (CO)	Unit of measurement: ppm Measurement accuracy: ≤ ± 5% Measuring range: 0 – 10 000 ppm
5.9.	Carbon dioxide (CO <sub>2</sub> )	Unit of measurement: ppm Measurement accuracy: ≤ ± 5% Measuring range: 0 – 10 000 ppm

6.	Total amount of combustible gases in the oil (H <sub>2</sub> , CO, CH <sub>4</sub> , C <sub>2</sub> H <sub>6</sub> , C <sub>2</sub> H <sub>4</sub> and C <sub>2</sub> H <sub>2</sub> )	Unit of measurement: ppm
7.	Gas ratio (according IEC 60599)	Representation for at least 4 gas ratios: C <sub>2</sub> H <sub>2</sub> /C <sub>2</sub> H <sub>4</sub> CH <sub>4</sub> /H <sub>2</sub> C <sub>2</sub> H <sub>4</sub> /C <sub>2</sub> H <sub>6</sub> CO <sub>2</sub> /CO
8.	Rate of change measurements	At least 1 day, 1 week and 1 month rate of change for individual gas must be provided.
9.	Water content in oil analyser (H <sub>2</sub> O)	Unit of measurement: ppm Measurement accuracy: $\leq \pm 10 \%$
10.	Permissible ambient temperature	At least from - 35 °C to + 40 °C
11.	Oil temperature in connection	At least from 0 °C to + 90 °C
12.	Permissible ambient humidity	At least from 0 % to 95 % RH
13.	Warning signal	It should be possible to set a warning signal for each measured gas and for rapid changes in each gas. Rate of change at least 1 day, 1 week 1 month for each gas.
14.	Data storage in device	At least 10 years with the possibility to download data
15.	Digital communication/ protocols	Ethernet (RJ45) Modbus TCP
16.	Supply voltage	AC: 100 – 240 V 50 Hz DC: 110 – 220 V (DC preferred)
17.	IP class	At least IP 56
18.	Certification	Calibration certificate, Proof of verification, CE (Conformité Européenne) marking
19.	Documentation	Installation and operating instructions, to the extent that the Customer can independently install and adjust the equipment.
20.	Analytic and visualization functions	Device must be equipped with web interface and including DGA diagnostics (data display in Duval triangles)

To reduce the number of monitoring systems, the monitoring of the main offer and option 1 can be combined as one monitoring system.

Option 1 shall be priced in the tender separately.

## 16.2 Option 2: On-line partial discharge (PD) and additional parameter monitoring system

The supply of option 2 shall include installation of an on-line partial discharge (PD) ) and additional parameter monitoring system for each unit of the two (2) new GSU transformers. The system shall cover each phase and each bushing and shall be based on both capacitive measurement and UHF measurement. The transformer monitoring system shall be in accordance with IEEE C57.143 and IEC 60076.

In option 2, the Contractor is encouraged to propose a PD monitoring system that works well with the Contractor's transformers and where good experience has been gained within other deliveries.

The on-line monitoring system should be capable of monitoring additionally such parameters as:

- Tan Delta monitoring:
  - TanDelta degradation over time
  - Absolute Tan Delta (6 bushings HV & LV)
  - Relative Tan Delta
- Bushing monitoring:
  - Temperature of the bushing
  - Bushings currents and current imbalance
  - Leakage current of each bushing
  - Bushing Capacitance measurement
  - Fast change in bushing capacitance

The measured values must be presented in a clear and understandable way and include trend analysis.

The monitoring system must meet EMC compliance according EN 61000 family of standards.

The monitoring system communication shall be based on standardized and established open communication protocols in accordance with IEC standards.

The monitoring system shall be provided with fibre optic and electrical connection interface, Ethernet. Monitoring system shall be connected to station control system.

The monitoring system shall be provided with all necessary accessories, software and documentation needed for operation of the system.

Requirements for online monitoring system:

1.	Data storage in device	At least 10 years with the possibility to download data
2.	Digital communication/ protocols	Ethernet (RJ45) Modbus TCP

3.	Supply voltage	AC: 100 – 240 V 50 Hz DC: 110 – 220 V (DC preferred)
4.	IP class	At least IP 56
5.	Certification	Calibration certificate, Proof of verification, CE (Conformité Européenne) marking
6.	Documentation	Installation and operating instructions, to the extent that the Customer can independently install and adjust the equipment.

To reduce the number of monitoring systems, the monitoring of the main offer and option 2 can be combined as one monitoring system.

Option 2 shall be priced in the tender separately.

## 17 Content of tender

The Contractor must provide sufficient information in the tender so that the Employer can evaluate the tender correctly. The Contractor must, among other things, include the following information in the tender:

- Description of manufacturing plant and test facilities.
- Description of manufacturing plant Quality Management System (QMS).
- Reference list and failure statistics from the last five (5) years.
- Rating, general data, etc. specified and compiled in a technical data sheet.
- Transformer total weight and oil volume.
- Curve showing apparent power in relation to water temperature at limitation of hot spot temperature to 98°C
- Outline drawing showing outer dimensions and tank dimensions (guaranteed with a tolerance of +200 mm).
- Outline drawing showing bushing locations and corresponding air clearances.
- Oil specification.
- Spare part list including unit prices.
- Recommended spare parts list (5 years operation) including unit prices.
- List of all deviations (deviations shall be accompanied with clear references).

## 18 Attachments

1. Drawing for existing 215 MVA transformers No 4 and 5
2. Network Code for the Electricity Sector (LV) 24.09.2020\_English translation
3. Layout plans of existing transformer rooms and cooling rooms

4. Rail interfaces, rail plans, MV busbar interfaces
5. Layout of PHPP territory with access roads
6. Document list