**TERMS OF REFERENCE**

**Project GF/Sri Lanka**

**Environmentally Sound Management and Disposal of**

**Polychlorinated Biphenyls Containing/Contaminated Equipment in Sri Lanka**

27 July 2022

# PROVISION OF ONE BRAND NEW MOBILE INSULATING OIL REGENERATION PLANT (Lot 1) AND TWO BRAND NEW MOBILE INSULATING OIL FILTRATION/DEHYDRATION PLANTS (Lot 2) FOR TRANSFORMERS AND WITCHGEARS FOR USE BY CEYLON ELECTRICITY BOARD IN SRI LANKA

## I. GENERAL BACKGROUND INFORMATION

The United Nations Industrial Development Organization (UNIDO) is the specialized agency of the United Nations that promotes industrial development for poverty reduction, inclusive globalization and environmental sustainability. The mission of the United Nations Industrial Development Organization (UNIDO), as described in the Lima Declaration adopted at the fifteenth session of the UNIDO General Conference in 2013, is to promote and accelerate inclusive and sustainable industrial development (ISID) in Member States. The relevance of ISID as an integrated approach to all three pillars of sustainable development is recognized by the 2030 Agenda for Sustainable Development and the related Sustainable Development Goals (SDGs), which will frame United Nations and country efforts towards sustainable development in the next fifteen years. UNIDO's mandate is fully recognized in SDG-9, which calls to "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". Accordingly, the Organization's programmatic focus is structured in four strategic priorities: Creating shared prosperity; Advancing economic competitiveness; Safeguarding the environment; and Strengthening knowledge and institutions.

The Directorate of Environment and Energy (EAE), aims to integrate and scale-up the energy and environment activities focusing on supporting governments and industries to provide sustainable and resilient soft and hard infrastructure for industrial development, supporting industries to contribute to climate neutral circular economy, and supporting governments and industries in fulfilling national commitments under multinational climate and environmental agreements.

The Department of Environment (EAE/ENV) contributes to ISID and the implementation of the SDGs, in particular of SDG 9, by greening existing industries and products, as well as by facilitating creation of new green industries and products, and by minimizing resource use along value chains and during the lifetime of products, facilitating uptake of circular economy practices

The Industrial Pollution Mitigation Division (EAE/ENV/IPM) is responsible for supporting developing countries and countries with economies in transition to implement the Chemicals and Wastes obligations and requirements under the Basel, Rotterdam, and Stockholm Conventions and other relevant agreements, in particular where it relates to larger and formalized industries and sectors, and to leverage its experience to address industrial pollution mitigation in general.

The National Implementation Plan (NIP) for the Stockholm Convention of the Democratic Socialist Republic of Sri Lanka identified phase-out and disposal of PCBs as one of the priorities requiring immediate attention and action. The country signed the Convention on 05 September 2001 and ratified it on 22 December 2005. The rationale and objectives of the project originated from the priorities and key objectives established by the NIP.

The NIP identified the Ceylon Electricity Board (CEB) as the major holder of transformers in Sri Lanka, namely the Ceylon Electricity Boar (CEB), Lanka Electricity Company (Pvt) Ltd (LECO) and the Independent Power Producers (IPP). Table 1 summarizes the estimated number of transformers in these companies.

**Table 1. Composition and Ownership of Power Sector Transformers in Sri Lanka, (updated to 2020).**

| Type of Transformers | CEB | | | LECO | | IPP | | Total number of transformers in service | |
|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2015 | 2020 | 2005 | 2015 | 2005 | 2015 | 2005 | 2015 |
| Distribution | 15,261 | 19,398 | 31,312 | 2,708 | 3,885 | None | None | 17,969 | 23,283 |
| Generation | 107 | 316 | 225 | None | None | 74 | 90 | 181 | 406 |
| Transmission | 206 | 320 | 194 | None | None | None | None | 206 | 320 |
| Total | 15,574 | 20,034 | 31,731 | 2,708 | 3,885 | 74 | 90 | 18,356 | 24,009 |

In addition to the transformers identified in the electrical utility sector in the NIP, there are thousands of small distribution transformers being used by electricity users. The welding sector with an estimated number of more than 10,000 small shops and similar number of small distribution transformers also represents a significant source of PCB contaminated dielectric fluid.

Based on the number of transformers, potentially contaminated with PCBs, the management of PCBs in Sri Lanka was identified as one of the most important objective in the country's National Implementation Plan.

Although never produced PCBs, the specific problems related to PCB management and which the project aims to address include: (i) Lack of adequate legislation to control imports; (ii) Environmental impacts and baseline levels not adequately studied; (iii) Lack of sufficient resources for identification and analysis; (iv) Lack of acceptable treatment, disposal and storage systems for PCB contaminated oil and equipment; (v) Contaminated sites yet to be identified; and, (vi) Cross contamination of non-PCB oil with PCB oil. Also, the Government faces various constraints in solving the PCB problem: (i) low level of awareness and equally low level of resources allocated for information campaigns; (ii) weak enforcement mechanisms (lack of technical capability to detect and regulate PCBs in use and releases to the environment, and to control PCB imports); (iii) lack of sustained commitment from other government functionaries; and, need for increased private sector participation (e.g. unwillingness of PCB owners to pay for proper PCB treatment).

Sri Lanka requested UNIDO to assist the country in the implementation phase. As part of this implementation, UNIDO and MERE prepared a proposal on the Environmentally Sound Management and Disposal of PCBs Wastes and PCB Contaminated Equipment in Sri Lanka. The project objective is build capacity to introduce and implement a polychlorinated biphenyl (PCB) management system to reduce and/or eliminate releases from PCB waste stockpiles and PCB-containing equipment in an environmentally sound manner. The proposal was submitted to GEF and obtained its approval for implementation.

The overall objective of the project is to eliminate the use and releases of PCBs to the environment through the introduction of environmentally sound management measures. It aims to dispose, decontaminate or safeguard at least 1000 metric tons of PCB wastes, PCB-contaminated oil and equipment and address capacity building, awareness and policy issues.

As part of early activities planned in the project was to carry out a PCB inventory in the country's electrical system to identify the type and level of contamination that the equipment has and the treatment and disposal options available for the country. These activities showed two main holders of PCB contaminated transformers, namely the Ceylon Electricity Board (CEB) that is the electrical utility that generates, transmit and distribute the electricity in the country and the thousands of independent small welding shops scattered in Sri Lanka.

The updated number of the transformers owned and operated by CEB in Generation, Transmission and Distribution electrical system in Sri Lanka is given in Table 2.

**Table 2. Number of transformers in Distribution, Transmission and Generation Electrical System at CEB.**

| **Division** | **Number of Transformer** |
|---|---|
| Distribution | 30,524 |
| Transmission | 171 |
| Generation Hydro | 82 |
| Generation Thermal | 95 |
| **Total** | **30,872** |

Because of costs of replacement and the difficulties in acquiring quickly larger transformers, such as those used in generating and transmission stations, electrical utilities have established maintenance programs by which these larger transformers are monitored and properly maintained. Smaller distribution transformers however, are not maintained while in operation. The size of these transformers, the difficulties to access them, as they are usually in high up pole locations and relatively low cost make the owners of these transformers to operate them until failure.

Although the rate of failure of the electrical transformers in the CEB system is not available, it is generally accepted that about 2 to 3% of the distribution transformers fail in any distribution network every year.

Large electrical utilities accumulate large volumes of used transformer mineral oil. This oil requires purification before is loaded back in transformers. CEB is not an exception to this activity and must therefore

purify the used oil that had been removed from transformers before it is loaded in refurbished transformers.

It is widely accepted in the electrical utilities that much of the PCB contaminated transformer mineral oil was caused by the use of the same equipment for the purification of PCB contaminated oil and non-contaminated dielectrics fluid. Based on this possibility, it is extremely important that large electrical companies that have transformer maintenance programs carry out oil testing to determine the presence of PCBs and have dedicated oil purification systems to avoid the propagation of the PCB contamination problem.

To assist in the implementation of an environmentally sound management system in CEB, the Project Steering Committee has approved the acquisition of one transformer mineral oil regeneration plant and two transformer insulating oil filtration/dehydration plants for use by CEB. UNIDO has undertaken this initiative and is preparing the required documentation for the solicitation of proposals for the provision of such pieces of equipment.

By acquiring this transformer oil regeneration and filtration/dehydration systems, the Project will be assisting CEB to have dedicated equipment for the treatment of its dielectric fluid and reducing the or eliminating the possibility of further contaminating with PCBs the non-PCB contaminated transformer oil. Thus, the Project will be assisting the owner of the equipment and the Government of Sri Lanka in meeting its obligations under the Stockholm Convention and thus, will contribute to the global efforts to control toxic chemicals in general and eliminate PCBs in particular.

## II. THE SCOPE OF SUPPLY

The objective of the tender is to acquire:

- **LOT 1:** one (1) Mobile Insulating Oil Regeneration Plant, and
- **LOT 2:** two (2) Mobile Insulating Oil Filtration/Dehydration Plants for transformers and switchgears for by CEB to treat the non-PCBs dielectric fluid from its electrical network.

The required pieces of equipment shall be used by CEB to dehydrate, degasify, filtrate and regenerate used mineral oil insulating oil to its original or near original characteristics to make it suitable for re-use in transformers and switchgears. Both, the Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants must be able to operate treating insulating oil from the electrical equipment while the electrical equipment continues to operate (on-line) and to treat oil stored in facilities within the Ceylon Electrical Board network.

While partial bidding and split award by Lot is possible, for each offered Lot Bidders are requested to provide a complete technical and commercial offer for each and every equipment and services listed in the respective Lot. Incomplete offers by Lot may be disregarded.

In view of the above, both LOTs, where offered, the Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants to be supplied MUST meet the following design, manufacturing, testing and operating conditions:

### 1.0 SYSTEM PARAMETERS

The Ceylon Electricity Board distribution system has two levels of Medium Voltage (MV), namely 11kV and 33kV. The Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants shall be used to treat the oil in the transformers of both levels of MV. The system parameters in CEB distribution network are summarized in Table 3:

**Table 3. CEB Electrical Distribution Network Parameters**

| System Parameter | Level A | Level B |
|---|---|---|
| Medium Voltage (MV) | 11 kV | 33 kV |
| High Voltage (HV) | 132 kV | 220 kV |

| | | |
|---|---|---|
| Low Voltage (LV) | 415 V | 415 V |
| Frequency | 50 Hz. | 50 Hz. |
| Number of Phases | 03 | 03 |
| Method of Earthing | Effectively earthed | Non-effectively earthed |
| System Faults Level | 12.5 kA rms | 16 kA rms |

## 2.0 SERVICE CONDITIONS

The Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants shall be used under the environmental and climatic conditions found in Sri Lanka. A summary of these conditions are given Table 4 below:

**Table 4. Environmental and Climatic Conditions to be Encountered during Operation of Mobile Insulating Oil Regeneration Plant and Mobile Insulating Oil Filtration/Dehydration Plants in Sri Lanka.**

| | | |
|---|---|---|
| (a) | Average ambient temperature | 15 °C to 30 °C |
| (b) | Maximum ambient temperature | 40 °C |
| € | Maximum relative humidity | 90% |
| (d) | Environmental conditions | Humid tropical climate with heavily polluted atmosphere |
| (e) | Operational altitude | From M.S.L. to 1900 m above M.S.L. |
| (f) | Isokeraunic (Thunder days) level | 100 days |

## 3.0 APPLICABLE STANDARDS

The equipment and components supplied shall be designed and constructed to meet and operate in accordance with the latest editions of the standards specified in Table 5 below and amendments thereof.

**Table 5. Applicable Standards to be met during operation of the Mobile Insulating Oil Regeneration Plant and Mobile Insulating Oil Filtration/Dehydration Plants in Sri Lanka.**

| | | |
|---|---|---|
| (a) | IEC 60422:2013 | Mineral insulating oils in electrical equipment - Supervision and maintenance guidance. |
| (b) | IEC 60156:1995 | Insulating liquids - Determination of the breakdown voltage at power frequency - Test method. |
| (c) | IEC 60814: 1997 | Insulating liquids - Oil-impregnated paper and pressboard - Determination of water by automatic coulometric Karl Fischer titration. |
| (d) | IEC 60296:2012 | Fluids for electro technical applications – Unused mineral insulating oils for transformers and switchgear. |
| (e) | ASTM D2945:2003 | Standard Test Method for Gas Content of Insulating Oils. |

## 4.0 TECHNICAL REQUIREMENTS

### 4.1 LOT 1: Mobile Insulating Oil Regeneration Plant

The Mobile Insulating Oil Regeneration Plant shall be suitable for treating used Transformer/Switchgear oil passing through specially designed filter, which dehydrate, degasify and remove sulfur and other chemical impurities from the oil and meeting the performance specifications for the Mobile Insulating Oil Regeneration Plant given in Table 6 below:

**Table 6. Performance Specifications for the operation of the Mobile Insulating Oil Regeneration Plant when processing used transformer oil in CEB electrical Network.**

| Parameter | Value after Processing |
|---|---|
| Breakdown Voltage (Across 2.5mm gap) | Minimum 80 kV |
| Moisture Content | 5 PPM |
| Suspended Particles | Less than 1 micron |
| Gas Content | 0.1% by Volume |
| Acidity | 0.08 mg KOH/g of Oil |
| Maximum Dielectric Dissipation Factor (DDF) 90 °C (Tan δ) | <0.005 |
| Dielectric Strength | 40 kV |
| Power Factor at 100°C | 0.4 |
| Sludge (Maximum) after 164h at 120°C | 0.8% max |
| Flash point (minimum) | 140°C |

### 4.2 LOT 2: Mobile Insulating Oil Filtration/Dehydration Plants

The Mobile Insulating Oil Filtration/Dehydration Plants shall be suitable for treating used Transformer/Switchgear oil passing through specially designed filter which dehydrate and degasify the oil and meeting the performance specifications for the Mobile Insulating Oil Filtration/Dehydration Plant given in Table 7 below:

**Table 7. Performance Specifications for the operation of the Mobile Insulating Oil Filtration/Dehydration Plants when processing used transformer oil in CEB electrical Network**

| Parameter | Value after Processing |
|---|---|
| Breakdown Voltage (Across 2.5mm gap) | Minimum 80 kV |
| Moisture Content | 5 PPM |
| Suspended Particles | Less than 1 micron |
| Gas Content | 0.1% by Volume |
| Acidity | 0.08 mg KOH/g of Oil |

## 5.0 BASIC FEATURES

The basic features of the required Mobile Insulating Oil Regeneration Plant and Mobile Insulating Oil Filtration/Dehydration Plants are given below:

### 5.1 LOT 1: Mobile Oil Regeneration Plant

#### 5.1.1 General

It is required to dehydrate and regenerate wet transformers/switchgears insulating oil while the equipment continues the online operation. The system shall require minimum of down time for connection and removal of the filtering unit. The filtering system shall be capable of reduction of total water content of oil to 10ppm or less in a single pass.

The unit shall reduce the moisture content of the cellulose insulation in the transformer by using heat generated by the transformer under load to transfer moisture from the wet insulation into the dried oil. The unit shall also be able to remove oxidation byproducts in a clay-type of column to restore dielectric properties and colour of the insulating oil.
The unit shall have minimum and maximum capacities of treating 500 and 1500 liters of insulating oil per hour respectively. The unit shall be equipped with variable flow control system that allows the operator to control and maintain the oil flow in the range of 500LPH to1500 LPH.

The manufacturer of insulating oil regeneration plant shall guarantee that flow rate of oil through the filtering plant shall not create any turbulence inside the transformer/switchgear. If a filter cartridge is used in the system, it must be non-migratory.

The unit shall be mounted inside a National Electrical Manufacturers Association (NEMA) 4 enclosure and suitable for outdoor tropical environment. A hinged, lockable door shall provide access to the

system. The enclosure shall have a hinged cover to allow clearance during cartridge changes (if required), and a bottom drain. All gauges and controls shall be visible through a view window mounted to the door of the enclosure. All valves shall be accessible from the front of the unit. The unit shall be painted with oven-cured, high corrosion resistant, polyester polyurethane powder coat paint suitable for tropical outdoor conditions.

The unit shall be mounted on a double-axle, double wheeled semi-trailer and the trailer shall be built with two (2) side door entrances and two (2) removable aluminum staircase sets with railing that can be stored and secured under the trailer when the unit is transported to a different site.

A Programmable Logic Controller (PLC) interfaced with a Supervisory Control and Data Acquisition (SCADA) shall be included in the design and manufacturing of the insulating oil regeneration unit. The PLC shall be used to monitor and control all aspects of the operation of the system.

A section of the trailer shall be separated from the operating site with a metallic wall, having a door to communicate both areas. One of the areas, the largest one, shall contain the oil regeneration unit components, while the smaller area shall contain a counter for oil testing equipment and the system's control panel. The control panel room shall be equipped with an air condition system.

### 5.1.2 Design

The system shall be designed for connection to an energized transformer/switchgear and shall be capable of continuous operation. The oil inlet pump of the filtering system shall be connected to the transformer bottom and the outlet oil of the system shall be pumped back into the top of the transformer. The system shall use non-migratory type cartridge filters to remove dissolved water. The system shall not use external heat or vacuum to complete the dehydration process. The unit shall also be capable of transferring oil without filtration.

The non-migratory type cartridge filter for the removal of dissolved water shall be last for the treatment of at least 150,000 kg of contaminated oil (independently of initial moisture content in the oil)

The plant shall be incorporated with Automatic filter regeneration for the removal of acidic and other dissolved contaminants. The large capacity adsorbent filters shall be automatically regenerated (re-dried) by the system through an internal process at regular intervals. Upon completion of the regeneration process, the system shall automatically restart in the moisture removal cycle.

Once the transformer/switchgear is dried out, it shall be possible to change the type of filter cartridge and continue the process to reduce the acidity in the transformer oil with transformer ON LINE and ON LOAD. The Filtration Plant shall be moveable with fixing of suitable wheels for towing by a crew cab/double cab.

### 5.1.3 Strainer

A strainer shall be installed on the inlet line of the dehydration plant up stream of the inlet pump and shall have mesh size sufficient to protect the pump from damage by dirt, debris and other foreign matter. The strainer shall be properly sized for rated minimum capacity of the pump.

### 5.1.4 Inlet Pump

The inlet pump shall be of positive gear pump type and shall be capable of delivering the minimum flow rate at rated output pressure. It is preferred to have rated pressure of the system at 70 psi for safety reasons.

The system shall be fitted with an internal adjustable pressure relief by pass mechanism to relieve the full pump flow and protect the system from excessive pressure. The pump shall be designed for continuous use.

### 5.1.5 Filter Housing

The filter housing shall be of welded carbon steel construction for maximum operating pressure of 100psi. The housing shall be capable of installation of equipment with sufficient redundancy for long

hours of operation required for dehydration process. There shall be manual air vent at the top of the housing and manual oil drain at the bottom of the housing. No special tools shall be required to open the covers of the filter housing. All covers shall be fitted with gaskets to seal under pressure conditions. A method shall be provided to vacuum the entire system of the equipment through a connection at the top of the filter housing.

A Clear Sight glass shall be fitted at the outlet of the system to indicate that oil flow is present in the system.

### 5.1.6 Adsorbent Clay Column

The adsorbent clay column shall be designed and built in a such a manner that allows the in-situ cleaning and regeneration of the solid adsorbent. The solid adsorbent to be used shall maintain its adsorption characteristics even after, at least 50 saturation cycles. The spent adsorption clay shall not be toxic in nature and shall be able to be disposed as non-toxic waste material.

### 5.1.7 Flow, Pressure and Temperature Measurement

A Digital flow meter shall be fitted in to the piping system to indicate the following,

- Rate of flow of oil through the system
- Total through put of oil
- Batch through put of oil (re-settable)

The flow meter shall turn on automatically when fluid flow starts and turns off a few minutes after flow has stopped.

The following gauges shall be mounted to the system,

- Pressure gauges to indicate pressure immediately downstream of the pump and before filter housing.
- Vacuum gauge
- Temperature gauge to indicate oil temperature at the discharge of the unit.

All gauges shall be liquid filled and accuracy of ± 1.5% full scale reading. Gauge tubing shall be 304 stainless steel tubing with JIC hydraulic connections.

### 5.1.8 Piping

All piping shall be of stainless steel with Joint Industry Council (JIC) as defined by the Society of Automotive Engineers (SAE J514) hydraulic connections and all piping shall be designed for the rated flow (500 to 1500 LPH) of the system. Threaded or welded fittings shall be avoided wherever possible. Galvanized fittings are not accepted.

### 5.1.9 Connection Hoses

Two quick coupling type hoses for input and output of the plant with length of at least 25 feet shall be provided.

These connection hoses shall be of coaxial type with inner oil flow hose rated to at least 1250psi and transparent out containment hose of clear white. Normally closed hose end solenoid valves (with latching relay and remote alarm connection mounted in the control box) shall be provided. The solenoid valve on the discharge line shall be of slow closing type and there shall be a flow directional check valve mounted downstream of the discharge solenoid.

### 5.1.10 Protections for oil leaks in to the Filtration Plant Housing

A float switch (with control relay mounted in the control box) shall be installed at the bottom of the system enclosure. Oil leaking from the inner flow hose shall be collected by the outer containment hose and shall run back into the system enclosure. If oil accumulates in the bottom of the enclosure either due to leakage of an oil flow hose or other leak in the system, the float switch shall signal the unit to shut off. The hose end solenoid valves shall be wired to open when the system is turned on and to shut when either the unit is turned off or an alarm condition shuts the unit off. A red alarm light

shall be mounted to the control box door to indicate that the unit has shut off due to high oil level at the bottom of the enclosure. It is preferable to have an audio alarm at the control panel together with the red alarm signal.

It shall be possible to pump back the oil from the drain of the filtration plant housing in to the transformer during maintenance of the filter housing using the same pumps used in the inlet of the filtration plant housing. Apart from the above there shall be system isolation valves at the inlet and outlet to the system and these valves shall not offer any restriction to the maximum flow rate of the system.

### 5.1.11 Oil Sampling

Sample ports for oil entering the filter housing and oil leaving the filter housing shall be provided. Sample ports shall be of stainless steel and it is preferable to have goose neck type valve sample ports.

### 5.1.12 Electrical Wiring

All wiring shall be of oil resistant type and shall be rated to the maximum currents and voltages of the system. Liquid tight flexible conduit shall protect all exposed wiring between the control box and motors. All wiring shall be terminated at a terminal block.

### 5.1.13 Power Supply

The system shall run on three phase, 415V AC, 50Hz power. Full load current shall be restricted to maximum of 16Amp and Power cord with standard plug top shall be provided for the power connection. The power cord shall be at least 25feet long.

### 5.1.14 Motors

#### 5.1.14.1 Oil Pump Motor

Oil pump motor shall be designed to drive the pump to deliver oil at maximum rated capacity. It shall be designed for continuous operation and shall be suitable for tropical out door operations. The motor shall be totally enclosed fan cooled design. Motor shall operate satisfactorily at all supply voltages between 85% and 110% of the rated voltage 415V, 50Hz. Motor shall be provided with adequate protection.

#### 5.1.14.2 Vacuum Pump Motor

The vacuum pump motor shall be designed to operate the vacuum pump at rated capacity. The motor shall be totally enclosed fan cooled design. Motor shall operate satisfactorily at all supply voltages between 85% and 110% of the rated voltage 415V, 50Hz. Motor shall be provided with adequate protection.

### 5.1.15 Operating Cubicle

All the operating switches, relays, wiring terminations and other ancillary components as described below shall be mounted inside the operating cubicle which shall be of NEMA 4 enclosure. The components shall consist of:

- Motor starters with overload protection and manual reset.
- Programmable Logic Controller to control all system functions
- Fuses (MCB) to protect motors and control circuit.
- Push button start/stop switches of the plant and individual motors, on panel door.
- Alarm indications for low flow, high pressure of pump, low oil level in the transformer, on panel door.
- Alarm reset button on panel door
- Hour meter to indicate total running hours, on panel door.

### 5.1.16 Oil Flow Low Switch

An oil flow low sensor shall be installed in the discharge line of the filtering plant. The sensor shall signal the PLC to shut down the plant after a time delay (to be set by the manufacturer) if the oil flow rate is less than the system operator's specified minimum value.

### 5.1.17 Transformer Oil Level Low

Operating cubicle shall have facility (a dry contact relay or PLC relay) to accept a signal from the transformer oil level low alarm circuitry and activate the filtering plant shut down in the event of oil level low in the transformer. A red alarm light shall be mounted on the control box door to indicate that the unit has shut down due to low oil level in the transformer.

### 5.1.18 Moisture Sensor

A moisture sensor shall be incorporated to give direct readings of moisture content in oil in parts per million or relative saturation as a percentage and the temperature of oil. The sensing probe shall be installed in the outlet line of the filtering unit and shall be able to sense the moisture content of the outgoing oil.

The sensor shall give a continuous reading with a digital display. The sensor shall give an alarm to indicate if filter cartridges are required to be changed when the moisture content exceeds a preset value. Volt free contacts shall be provided for the activation of remote alarm installed by the user.

5.1.19 Identification of Components

Labels written in English language shall be provided for all instrument relays, control switches, push buttons, indicating lights etc. Relays shall be clearly labeled according to their function. Labels shall preferably be on a white background with black engraved letters.

## 5.2 LOT 2: Mobile Insulating Oil Filtration/Dehydration Plants

### 5.2.1 General

It is required to dehydrate wet transformers/switchgears while the equipment continues the on line operation. The system shall require minimum of down time for connection and removal of the filtering unit. The filtering system shall be capable of reduction of total water content of oil to 10ppm or less in a single pass.

The unit shall reduce the moisture content of the cellulose insulation in the transformer by using heat generated by the transformer under load to transfer moisture from the wet insulation into the dried oil. It shall have throughput capacity to treat a minimum of 500 LPH and a maximum of 1,500 LPH, independently of the initial conditions of the insulating oil.

The flow of the oil through the filtering/dehydration unit shall be controlled with the variable flow control and provide steady flow in the range of 500 to 1,500 LPH.

The manufacturer of filtering plant shall guarantee that flow rate of oil through the filtering plant shall not create any turbulence inside the transformer/switchgear.. If a filter cartridge is used in the system, this must be non-migratory. The filter shall be able to last for the treatment of at least 150,000 litres of insulating oil (independently of initial moisture content in the oil) before replacement.

The unit shall be mounted inside a National Electrical Manufacturers Association (NEMA) 4 enclosure and suitable for outdoor tropical environment. A hinged, lockable door shall provide access to the system. The enclosure shall have a hinged cover to allow clearance during cartridge changes (if required), and a bottom drain. All gauges and controls shall be visible through a view window mounted to the door of the enclosure. All valves shall be accessible from the front of the unit. The unit shall be painted with oven-cured, high corrosion resistant, polyester polyurethane powder coat paint suitable for tropical outdoor conditions.

A Programmable Logic Controller (PLC) interfaced with a Supervisory Control and Data Acquisition

(SCADA) shall be included in the design and manufacturing of the insulating oil regeneration unit. The PLC shall be used to monitor and control all aspects of the operation of the system.

### 5.2.2 Design

The system shall be designed for connection to an energized transformer/switchgear and shall be capable of continuous operation. The oil inlet pump of the filtering system shall be connected to the transformer bottom and the outlet oil of the system shall be pumped back into the top of the transformer. The system shall be equipped with a non-migratory type cartridge filters to remove dissolved water. The system shall not use external heat or vacuum to complete the dehydration process. The unit shall also be capable of transferring oil without filtration.

The plant shall be incorporated with Automatic filter regeneration. The large capacity adsorbent filters shall be automatically regenerated (re-dried) by the system through an internal process at regular intervals. Upon completion of the regeneration process, the system shall automatically restart in the moisture removal cycle..

Once the transformer/switchgear is dried out it shall be possible to change the type of filter cartridge and continue the process to reduce the acidity in the transformer oil with transformer ON LINE and ON LOAD. The Filtration Plant shall be moveable with fixing of suitable wheels for towing by a crew cab/double cab.

### 5.2.3 Strainer

A strainer shall be installed on the inlet line of the dehydration plant up stream of the inlet pump and shall have mesh size sufficient to protect the pump from damage by dirt, debris and other foreign matter. The strainer shall be properly sized for rated minimum capacity of the pump.

### 5.2.4 Inlet Pump

The inlet pump shall be of positive gear pump type and shall be capable of delivering the minimum flow rate at rated output pressure. It is preferred to have rated pressure of the system at 70 psi for safety reasons.

The system shall be fitted with an internal adjustable pressure relief by pass mechanism to relieve the full pump flow and protect the system from excessive pressure. The pump shall be designed for continuous use.

### 5.2.5 Filter Housing

The filter housing shall be of welded carbon steel construction for maximum operating pressure of 100psi. The housing shall be capable of installation of equipment with sufficient redundancy for long hours of operation required for dehydration process. There shall be manual air vent at the top of the housing and manual oil drain at the bottom of the housing. No special tools shall be required to open the covers of the filter housing. All covers shall be fitted with gaskets to seal under pressure conditions. A method shall be provided to vacuum the entire system of the equipment through a connection at the top of the filter housing.

A Clear Sight glass shall be fitted at the outlet of the system to indicate that oil flow is present in the system.

### 5.2.6 Flow, Pressure and Temperature Measurement

A Digital flow meter shall be fitted in to the piping system to indicate the following,

- Rate of flow of oil through the system
- Total through put of oil
- Batch through put of oil (re-settable)

The flow meter shall turn on automatically when fluid flow starts and turns off a few minutes after flow has stopped.

The following gauges shall be mounted to the system,

- Pressure gauges to indicate pressure immediately downstream of the pump and before filter housing.
- Vacuum gauge
- Temperature gauge to indicate oil temperature at the discharge of the unit.

All gauges shall be liquid filled and accuracy of ± 1.5% full scale reading. Gauge tubing shall be 304 stainless steel tubing with JIC hydraulic connections.

### 5.2.7 Piping

All piping shall be of stainless steel with Joint Industry Council (JIC) as defined by the Society of Automotive Engineers (SAE J514) hydraulic connections and all piping shall be designed for the rated flow (500 to 1500 LPH) of the system. Threaded or welded fittings shall be avoided wherever possible. Galvanized fittings are not accepted.

### 5.2.8 Connection Hoses

Two quick coupling type hoses for input and output of the plant with length of at least 25-feet shall be provided.

These connection hoses shall be of coaxial type with inner oil flow hose rated to at least 1250psi and transparent out containment hose of clear white. Normally closed hose end solenoid valves (with latching relay and remote alarm connection mounted in the control box) shall be provided. The solenoid valve on the discharge line shall be of slow closing type and there shall be a flow directional check valve mounted downstream of the discharge solenoid.

### 5.2.9 Protections for oil leaks into the Filtration Plant Housing

A float switch (with control relay mounted in the control box) shall be installed at the bottom of the system enclosure. Oil leaking from the inner flow hose shall be collected by the outer containment hose and shall run back into the system enclosure. If oil accumulates in the bottom of the enclosure either due to leakage of an oil flow hose or other leak in the system, the float switch shall signal the unit to shut off. The hose end solenoid valves shall be wired to open when the system is turned on and to shut when either the unit is turned off or an alarm condition shuts the unit off. A red alarm light shall be mounted to the control box door to indicate that the unit has shut off due to high oil level at the bottom of the enclosure. It is preferable to have an audio alarm at the control panel together with the red alarm signal.

It shall be possible to pump back the oil from the drain of the filtration plant housing in to the transformer during maintenance of the filter housing using the same pumps used in the inlet of the filtration plant housing. Apart from the above there shall be system isolation valves at the inlet and outlet to the system and these valves shall not offer any restriction to the maximum flow rate of the system.

### 5.2.10 Oil Sampling

Sample ports for oil entering the filter housing and oil leaving the filter housing shall be provided. Sample ports shall be of stainless steel and it is preferable to have goose neck type valve sample ports.

### 5.2.11 Electrical Wiring

All wiring shall be of oil resistant type and shall be rated to the maximum currents and voltages of the system. Liquid tight flexible conduit shall protect all exposed wiring between the control box and motors. All wiring shall be terminated at a terminal block.

### 5.2.12 Power Supply

The system shall run on three phase, 415V AC, 50Hz power. Full load current shall be restricted to maximum of 16Amp and Power cord with standard plug top shall be provided for the power connection. The power cord shall be at least 25-feet long.

### 5.2.13 Motors

#### 5.2.13.1 Oil Pump Motor

Oil pump motor shall be designed to drive the pump to deliver oil at maximum rated capacity. It shall be designed for continuous operation and shall be suitable for tropical out door operations. The motor shall be totally enclosed fan cooled design. Motor shall operate satisfactorily at all supply voltages between 85% and 110% of the rated voltage 415V, 50Hz. Motor shall be provided with adequate protection.

#### 5.2.13.2 Vacuum Pump Motor

The vacuum pump motor shall be designed to operate the vacuum pump at rated capacity. The motor shall be totally enclosed fan cooled design. Motor shall operate satisfactorily at all supply voltages between 85% and 110% of the rated voltage 415V, 50Hz. Motor shall be provided with adequate protection.

### 5.2.14 Operating Cubicle

All the operating switches, relays, wiring terminations and other ancillary components as described below shall be mounted inside the operating cubicle which shall be of NEMA 4 enclosure. The components shall consist of:

- Motor starters with overload protection and manual reset.
- Programmable Logic Controller to control all system functions
- Fuses (MCB) to protect motors and control circuit.
- Push button start/stop switches of the plant and individual motors, on panel door.
- Alarm indications for low flow, high pressure of pump, low oil level in the transformer, on panel door.
- Alarm reset button on panel door
- Hour meter to indicate total running hours, on panel door.

### 5.2.15 Oil Flow Low Switch

An oil flow low sensor shall be installed in the discharge line of the filtering plant. The sensor shall signal the PLC to shut down the plant after a time delay (to be set by the manufacturer) if the oil flow rate is less than the system's operator specified set minimum value.

### 5.2.16 Transformer Oil Level Low

Operating cubicle shall have facility (a dry contact relay or PLC relay) to accept a signal from the transformer oil level low alarm circuitry and activate the filtering plant shut down in the event of oil level low in the transformer. A red alarm light shall be mounted on the control box door to indicate that the unit has shut down due to low oil level in the transformer.

### 5.2.17 Moisture Sensor

A moisture sensor shall be incorporated to give direct readings of moisture content in oil in parts per million or relative saturation as a percentage and the temperature of oil. The sensing probe shall be installed in the outlet line of the filtering unit and shall be able to sense the moisture content of the outgoing oil.

The sensor shall give a continuous reading with a digital display. The sensor shall give an alarm to indicate if filter cartridges are required to be changed when the moisture content exceeds a preset value. Volt free contacts shall be provided for the activation of remote alarm installed by the user.

### 5.2.18 Identification of Components

Labels written in English language shall be provided for all instrument relays, control switches, push buttons, indicating lights etc., Relays shall be clearly labeled according to their function. Labels shall preferably be on a white background with black engraved letters.

## 6.0 ADDITIONAL REQUIREMENTS

### 6.1 Supplier Experience

The supplier shall have a minimum of 10 years of successful experience in manufacturing and/or distributing Mobile Insulating Oil Regeneration Plant and Mobile Insulating Oil Filtration/Dehydration Plants for transformers and switchgears.

In addition, the supplier shall also have a minimum of 5 years of experience in manufacturing and/or delivering orders from outside its country of establishment.

The supplier shall provide adequate documentary evidence to comply with above requirements. Bids non complying with above requirements or with incomplete evidence of compliance would be rejected.

### 6.2 Tools and Spare Parts

The Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants for transformers and switchgears shall be designed and manufactured with rugged parts to minimize and simplify maintenance procedures.

The supplier shall also furnish within the scope of supply/offer replacement parts for components that according to Manufacturer, have limited useful life and this useful life is expected to be fulfilled within the 36-month warranty period (for example, water filter cartridges, gaskets, seals, etc.).

In addition to the above, the supplier shall furnish a list, as recommended by the Manufacturer giving full particulars, including quantities, available sources and current prices of spare parts, etc., necessary for the proper and continuing functioning of the Equipment during and beyond the warranty period.

### 6.3 A company Brochure, Outline Drawings, Maintenance Manual and Packing

Printed Company brochure covering details of manufacturing and quality assurance procedures and complete list of models of similar equipment shall be provided with the bid.

Two copies of operating and maintenance manual together with all relevant drawings and circuit diagrams shall be a part of the offer.

Operating and maintenance manual shall have all necessary instruction for operating and maintenance including the following,

- A general description of the equipment with particular attention to the technical description of its characteristics and operation.
- A description of the safety features of the equipment and the operation of interlocks.
- As relevant a description of the action to be taken during operation, isolation, earthing, maintenance and testing.
- Recommended environment for maintenance (indoor, outdoor, in factory, on site etc.,) and procedure for inspection and maintenance.
- Description of special equipment or tools required for the maintenance work.
- Description of safety precautions to be taken during operation and maintenance.
- Disposal procedure of the components such as filter cartridge at the end of their operating life.
- Maintenance manual shall include a list of all the component and consumables and ordering details.

### 6.4 Commissioning and Training

The supplier shall commission and test the units at Ceylon Electricity Board in Sri Lanka and provide the required on-site training to CEB's dedicated Operators. It is expected that CEB shall have at least two Operators per unit for a minimum of six Operators to be trained.

A hands-on training of three-day / two-day of is expected to be sufficient for CEB Operators to become competent on the operation of the Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants for transformers and switchgears.

### 6.5 Manufacturer's Authorization

If the supplier is not the designer/manufacturer of the Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants for transformers and switchgears to be supplied to UNIDO, the supplier shall provide proves that has entered into an agreement with the company that shall design and built the supplied equipment.

### 6.6 Maintenance & Repair after Delivery

In case that the supplier or its representative is not able to carry out necessary maintenance and repair of the Equipment after delivery in Sri Lanka, the supplier shall nominate an Agent in Sri Lanka equipped and able to carry out all maintenance, repair works associated with the equipment as per guidelines provided by the Manufacturer, not only during the warranty period but throughout the equipment's lifespan.

The supplier shall identify and provide a Letter of Agreement with a local Agent or Representative with the offer, should such situation arise. .

## 7.0 QUALITY ASSURANCE

The manufacturer shall possess ISO 9001 or similar Quality Assurance Certification for the manufacture of Insulating Oil Purifiers. Bidders shall furnish a copy of the ISO certificate of the original by the manufacturer, along with the offer.

## 8.0 INSPECTION AND TESTING

After awarding the contract and before the parts are assembled in the plants, the supplier shall provide to UNIDO a list of tests to be witnessed by UNIDO and/or project's stakeholders The list of tests shall include applicable standards and detail description of the test procedures to be applied.

The supplier shall make necessary arrangements for inspection of the equipment by an Engineer appointed by UNIDO and also to carry out in his presence necessary simulation and conventional tests of the machines and related accessories at no extra cost. Extra copies of routine test reports shall be made available at the time of inspection.

If the product fails to comply with requirements of this specification or aforesaid tests, UNIDO shall reject the product.
Installation and commissioning of the oil filtration plant, as well as training of local Operators shall be coordinated with UNIDO, project stakeholders and CEB.

The supplier, UNIDO and CEB shall agree on a testing protocol for the Mobile Insulating Oil Regeneration Plant and the two (2) Mobile Insulating Oil Filtration/Dehydration Plants. This testing protocol shall include the use of the provided plants on both, on the treatment of insulating in energized transformers and treatment of used oil in bulk storage at CEB facilities.

The testing protocol shall be carried out in triplicate to ensure the consistency operation of the plants and the testing of the treated insulating oil shall meet the requirements listed in Table 6 and Table 7 for the Mobile Insulating Oil Regeneration Plant and Mobile Insulating Oil Filtration/Dehydration Plants respectively.

The operation of the new plants during the testing protocol shall provide consistent results. This to be confirmed by three (3) consecutive runs where all parameters in Table 6 and 7 are met when testing Mobile Insulating Oil Regeneration Plant and the two (2) Mobile Insulating Oil Filtration/Dehydration Plants respectively.

## 9.0 INFORMATION TO BE FURNISHED WITH THE OFFER

In addition to what is requested in the Instructions to Bidders, for each offered Lot, the following Information shall be furnished in the technical offer.

a) Duly filled Technical Offer Form (Appendix 3.a of the tender documentation)
b) Company brochure and documentary evidence relevant to clause 6.3
c) Manufacturer's Authorization in accordance with Appendix 3.a of the tender documentation
d) Manufacturing Experience in accordance with clause 6.1
e) List of Tools and Spare Parts in accordance with clause 6.2
f) Acceptance Letter from the Agent for carrying out After Sales services in accordance with clause 6.6 as applicable.
g) Certified copy of the quality assurance conforming to ISO 9001.
h) Certified copies of Relevant Type Test reports.
i) Reports of chemical analysis of air emission from the plants when treating used transformer oil and regenerating in-situ filters and adsorbent materials.
j) Report of chemical analysis of byproducts being generated by the plants (for example, filter cartridges, spent adsorbent material, etc.
k) Mass balance of the plants, assuming the treatment of 150,000 kg of transformer oil with initial moisture content of 100 mg/kg or ppm. Please give details of any other assumption such as acidity content, particles, etc. in the initial oil.

## III. GUARANTEE REQUIREMENTS

The supplier shall provide a warranty that the equipment supplied as part of this Terms of Reference will be brand new, unused, and of the most recent or current model and it will perform free of defects or malfunctioning for a minimum of thirty-six (36) months from the date UNIDO issues the Certificate of Acceptance.

The supplier should guarantee the quality of the all services and technology performance in accordance with international practice and standards and as specified in the Terms of Reference. The safety guarantee should also be in accordance with international practice and standards.

The supplier should guarantee that the equipment to be used is in good working conditions and shall immediately repair or replace at its own expenses and as soon as practicable any defective goods/parts within the service operation period (36 months).

The supplier shall provide the details of local or national partner or agent in Sri Lanka. It is expected that the local or national partner or agent shall provide services and parts that may be required beyond the warranty period and within ten (10) years of UNIDO issuing of the Certificate of Acceptance.

The Ceylon Electricity Board as operator of the equipment shall directly or through UNIDO give notice to the supplier should any malfunctioning of the equipment occurs during the 36-month warranty period. The supplier, upon receiving such notice, shall promptly, within 30 day or less, fix the problem and restore the equipment to good operating conditions. As the failure of the equipment and subsequent repair of the same is within the warranty period, such repair shall be carried out as a responsibility of the supplier and at no cost to CEB nor to UNIDO.

## IV. PERSONNEL IN THE FIELD AND LANGUAGE REQUIREMENTS

The supplier shall provide key personnel with qualifications required for performing the requested activities for all on-site and off-site support activities. The curriculum vitae of each professional must be enclosed and justification of the qualifications of each member within the team shall be detailed.

All written communications with the Project must be in English. Members of the supplier's professional team must have working-level and communication skills in English or shall be assisted

by an authorized and skilled translator.

## V. DELIVERY TERMS

It is the sole responsibility of the supplier to transport and deliver the goods to the named place of destination (please refer to the delivery point outlined in section X of this document). The equipment should be delivered at said delivery point indicated in section IX. DELIVERY ADDRESS of this Terms of Reference in line with DAP (Incoterms 2010) conditions, including unloading, if necessary. The Contractor shall also insure the goods during their shipment and transit to the named place of destination and thereafter, until the packing crates are opened against all risks of loss or damage from any cause. The insurance shall cover the full price of the goods including freight costs plus ten percent (10%) and shall be in the currency of the Contract Price.

Upon delivery of the goods, commissioning, installation and training, the supplier is responsible to obtain the Certificate of Acceptance that the goods have been delivered in good conditions and that the commissioning, installation and training services, , were performed satisfactorily.

The goods shall be delivered to listed end-user as clearly outlined below. Two weeks before arrival at final destination, separate shipping notification needs to be provided to all parties involved. The supplier should pre-notify all below listed focal points as well as the UNIDO Country Office, the Procurement Services Division and Project Manager at UNIDO HQ. This shall allow all parties to take appropriate necessary action before delivery to the country.

## VI. DELIVERABLES AND TIMEFRAME

Table 8 below lists the deliverables and timeframe from the date the contract is signed. The duration of the Contract shall not exceed ten (10) months. The supplier shall prepare equipment for dispatch to the project site destination in adequate packaging and will prepare and submit a list of goods sent to the project site location listing the serial numbers when available.

**Table 8. Deliverables and Timeframe**

| **Deliverables/Activities** | **Months (10 months maximum)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **Permits to import equipment into Sri Lanka** | **X** | **X** | | | | | | | | |
| **Design of the Mobile Insulating Oil Regeneration Plant and of the Mobile Insulating Oil Filtration/Dehydration Plants** | **X** | **X** | **X** | | | | | | | |
| **Construction of the Mobile Insulating Oil Regeneration Plant and of the Mobile Insulating Oil Filtration/Dehydration Plants** | | **X** | **X** | **X** | **X** | **X** | **X** | | | |
| **Transportation of equipment to Sri Lanka** | | | | | | | | **X** | | |
| **Installation and commissioning of the plants** | | | | | | | | | **X** | |
| **Training of CEB Operators on the operation of Plants** | | | | | | | | | **X** | |
| **Conformance Performance Testing and Training** | | | | | | | | | | **X** |

## VII. REPORTING REQUIREMENTS

Reports shall be submitted to UNIDO in English. All deliverables/reports must be of such quality that no additional editing is required. The supplier's reporting requirements are given in Table 9 below:

**Table 9. Reporting and submission requirements**

| **Name of** | **Content** | **Indicative Time** |
|---|---|---|

| Report | | of Submission |
|---|---|---|
| **1st interim report** | -Schedule of proposed activities, including discussions with CEB Representatives in places and energized transformers where the Mobile Insulating Oil Regeneration Plant and the Mobile Insulating Oil Filtration/Dehydration Plants will be tested.<br>-Copy of letter from CEB confirming acceptance of schedule and identification of site where the Mobile Insulating Oil Regeneration Plant and Mobile Insulating Oil Filtration/Dehydration Plants will be first installed and commissioned.<br>-Copy of design drawings.<br>-Letter confirming the supplier has ordered/acquired major components for the Mobile Insulating Oil Regeneration Plant | **Three (3) months after signing of the contract** |
| **2nd interim report** | - Submission of report that includes details of the construction of the Mobile Insulating Oil Regeneration Plant and Mobile Insulating Oil Filtration/Dehydration Plants.<br>- Copy of shipping documents confirming the supplier has booked transportation of the plant from place of manufacturing to Ceylon Electricity Board site in Sri Lanka. | **Seven (7) months after signing of the contract** |
| **Final report and Certificate of Acceptance** | -Results of Conformance Performance testing confirming consistency with UNIDO's Acceptance Criteria<br>-Summary of training program, including names of trainees, procedures applied and results of tests confirming the treated oil meets the performance specifications required under this Terms of Reference.<br>- Certificate of Acceptance signed by the supplier, UNIDO and the end-user. | **Ten (10) months after signing of the contract** |

## VIII. SELECTED SUPPLIER'S RESPONSIBILITIES

The selected supplier shall be responsible, as applicable, for the delivery of the Mobile Insulating Oil Regeneration Plant and the Mobile Filtration/Dehydration Plants for the treatment of used transformer insulating oil spare parts, reagents and any components required to efficiently operate the plant at CEB selected site in Sri Lanka.

The selected supplier shall obtain, as applicable, any required permit to handle, package and transport the Mobile Insulating Oil Regeneration Plant and the Mobile Filtration/Dehydration Plants for the treatment of used transformer insulating oil, spare parts, ancillary equipment if any, reagents and all other materials to operate the plant in Sri Lanka.

The selected supplier shall be responsible for the provision of a local agent/partner to facilitate the service of the equipment, as required, and the provision all parts to repair the equipment in a timely manner as needed, in Sri Lanka.

## IX. DELIVERY ADDRESS

**Consignee:**

UNIDO,
c/o Resident Representative,
United Nations Development Programme (UNDP),
202-204 Bauddhaloka Mawatha, Colombo 7,
Sri Lanka.

Contact person: Ms.Sripalee de Silva

Mobile is 00 94 0774398386
Email : sripalee.desilva@undp.org

**End-user (delivery point):**
Kolonnawa 10600
Sri Lanka.

Complete detailed address and contact details will be share upon Contract signature.