

بسم الله الرحمن الرحيم

Conceptual Design & Specifications of
A Solar Pump Testing Facility
for
Sudan's Solar Water Pumps Project (SWP)

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1 INTRODUCTION

1.1 Foreword

Sudan's Solar Water Pumps Project (SWP) is acting to lead a gradual transformation of the privately-owned fuel-dependent irrigation schemes in Sudan towards photovoltaic pumping. The scheme aims to supply farmers within the coming few years with thousands of solar pumps.

To guarantee that the project follows a systematic and well-based approach, SWP assigned The Energy Research Center (ERC) of the University of Khartoum the task of designing a test facility in Khartoum for PV pumps and to oversee the procurement process, lab erection, system installment, commissioning of the facility and staff training.

This report embodies the details of the suggested testing facility. The specifications stated are intended to be handed to potential contractors and eventually to be implemented within SWP's time-frame for the project. The report includes a layout of the testing facility, specs of the lab components and other relevant information. In addition to the integrated PV pump test details, the report includes the required testing devices for some isolated system components. This extends the lab capabilities to beyond its main duty of testing integrated PV pumps.

In addition to the testing instrumentation, the report suggests provision of a full PV pumping system of reputable standard to serve as a training work-horse and to use for system commissioning and as a test reference system.

The testing facility is such that it can handle two tests simultaneously, meaning that two-line tests are possible.

The laboratory, as requested by the Client and as suggested in this report, is set to perform a full test for a complete PV pumping unit. The testing facilities may be upgraded as to test any separate component and to cover, as well, Stand-Alone PV systems. Details of such alternatives may be provided, once the current scheme is established and grasped by the lab operators.

1.2 Local Environment Data

#	Item	value
1	Location	15.5, 32.6
2	Ambient temperature ranges	Hottest month May: 26-42°C Coldest month January: 16-32°C.
	Altitude	390m a.s.l.
4	Irradiance	The maximum global insolation in Khartoum: 900 W/m ² . The mean daily global irradiance ranges between 220 W/m ² in December and 289 W/m ² in April.
5	Wind	Max wind speed: 25m/s Average: ~ 4.5m/s at 20m height

1.3 Scope of Testing

- i. Centrifugal multi-stage submersible pumps
- ii. Centrifugal surface pumps
- iii. Centrifugal float pumps
- iv. Helical positive-displacement
- v. Three-phase AC Induction motors
- vi. Single-phase AC Induction motors
- vii. D-C motors
- viii. Power range: 0.5 – 50kW.
- ix. Two testing lines in parallel.
- x. Automatic data sensing, monitoring, recording and storage.
- xi. **Durability Test:** All components of the system shall be subjected to extended full operation period during which consistency of output, temperature levels and all other relevant indicator are gauged to ensure reliability. The continuous running shall not be less than 4 hrs. if any appreciable temperature rise or data inconsistency is observed, then the time range is to be extended to pinpoint causes of inconsistency.

1.4 Liability Period

The Liability Period is one calendar year following a successful commissioning. 15% of the total Contract Price shall be withheld by the client pending a full clearance statement to be issued by the Consultant at the end of the Liability period.

2 THE CONCEPTUAL DESIGN

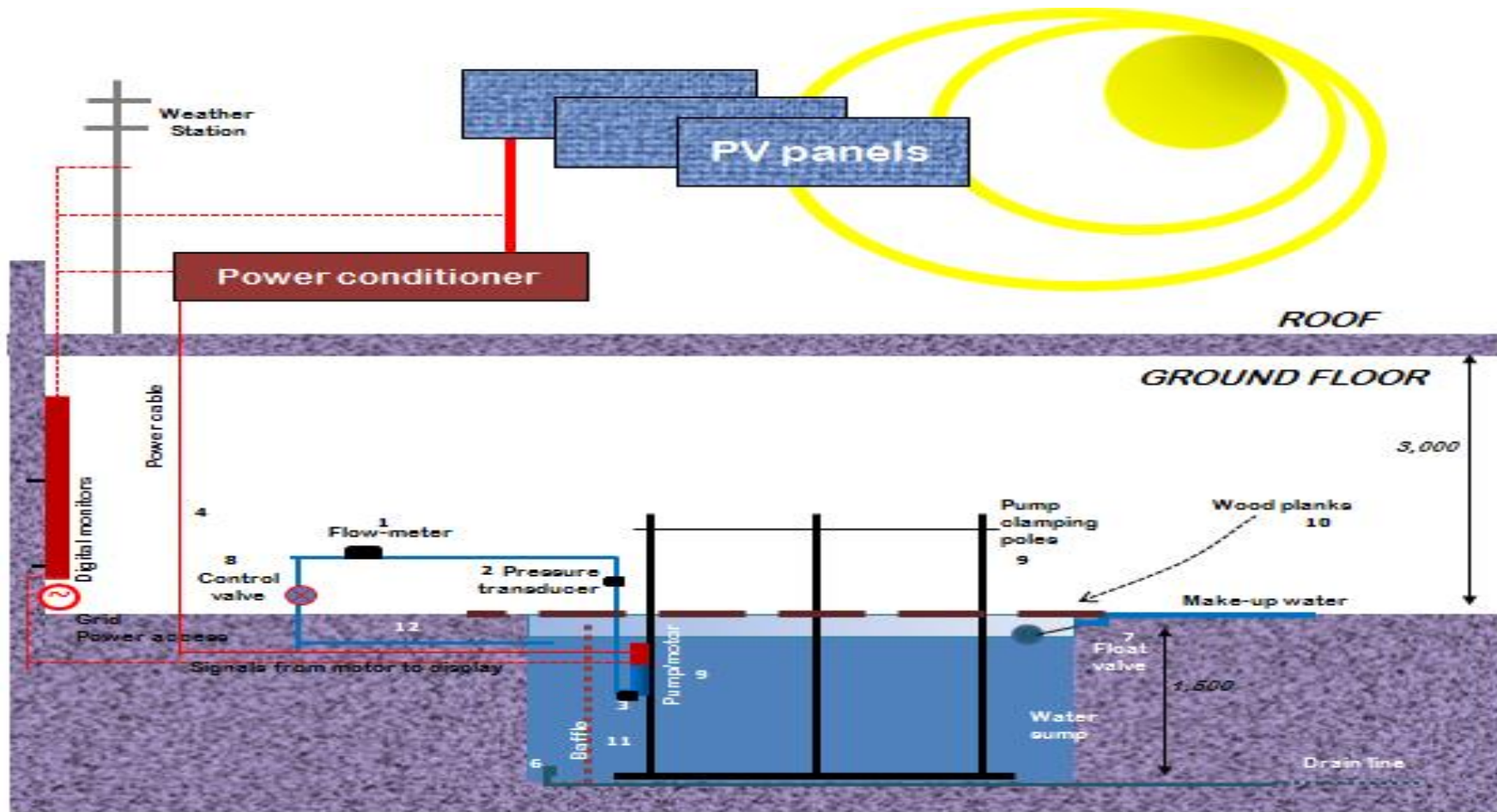


Fig.1: A schematic presentation of the two-level testing venue

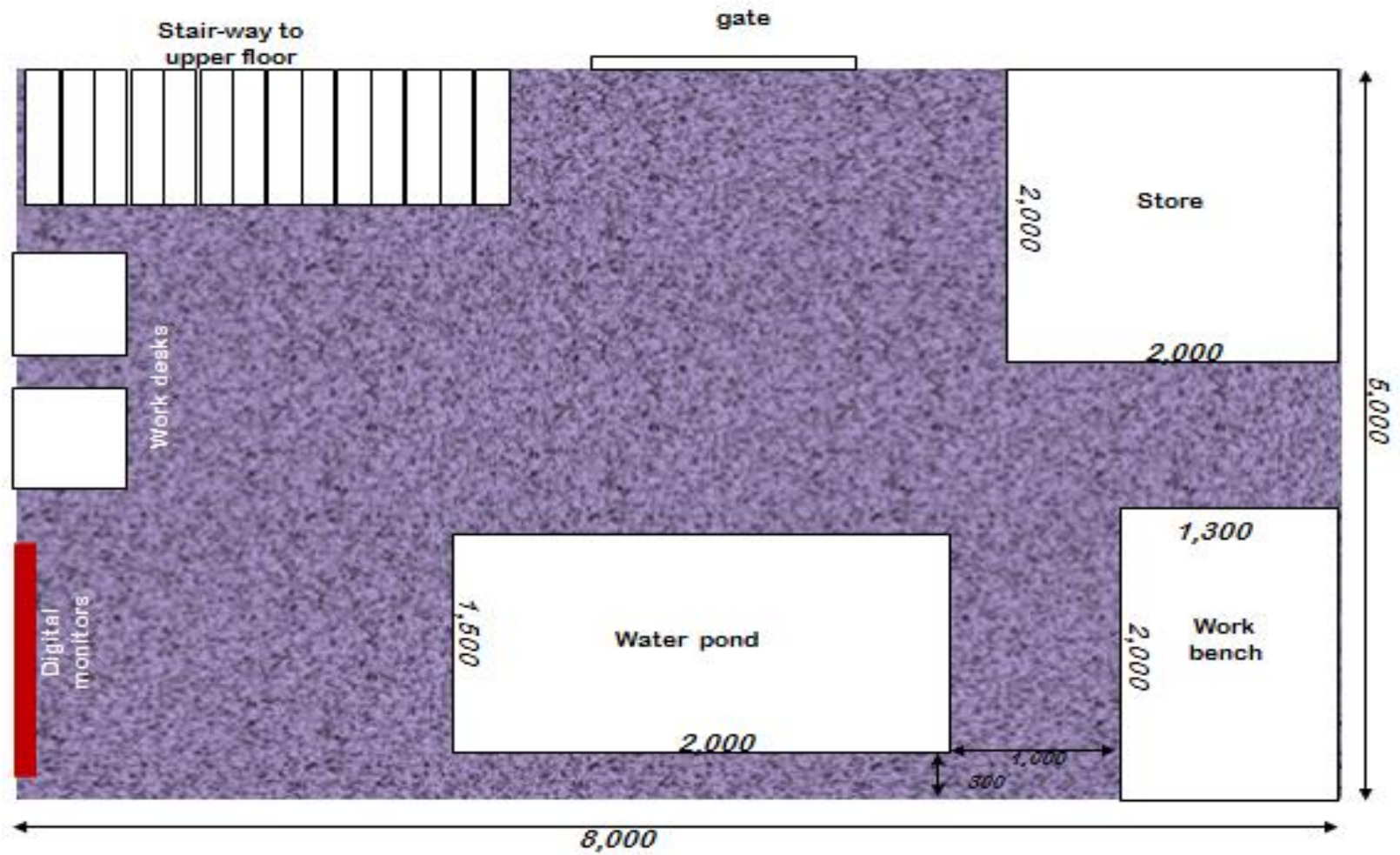


Fig.2: The conceptual design top-view of the lab's ground floor

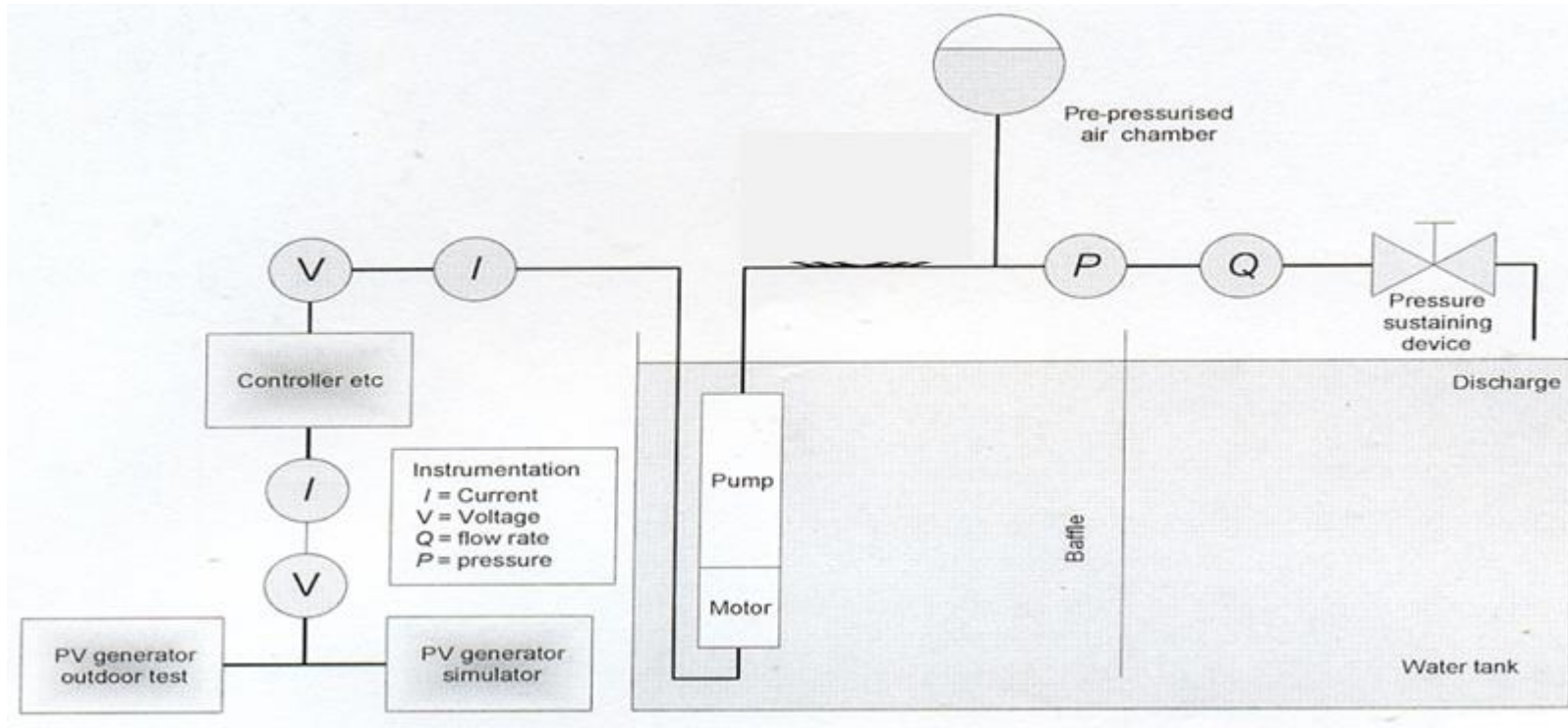


Fig.3: A schematic of the test system

3 BILL OF QUANTITIES

3.1 Pump Testers

#	Item	specs	No. off
1	Flow meter	i. Max. flow: 50L/s ii. Digital display transduced to Main panel [L/s], 100DN	2
2	Delivery pressure gauge	i. Max. pressure: 6bar ii. Digital display transduced to Main panel [bar]	2
3	Suction pressure gauge	i. Pressure range: -0.5 to 1bar ii. Digital display transduced to Main panel [bar]	2
4	Input power to Motor(Power analyzer meter) Measuring I, V and frequency)	Digital display on Main panel [W]	2
5	Inlet water temperature sensor	Digital display on Main panel [°C]	2
6	Drain submersible pump & accessories	Capacity: 5L/s at 1m head.	2
7	Float valve for sump water make-up	25DN	2
8	Control Valve	Globe, 100DN	2
9	Pump Clamping poles	Three 2m angles of common welded angle base. All material galvanized steel. Complete with appropriate pump-holding clamps.	2 lots
10	Wooden planks for sump cover	Rectangular wooden planks that serve work platform	2 lots
11	Flow Baffle to inhibit turbulence	Laminated galvanized gauze sheet: 1500x1400	2 lots
12	PVC Pipes and fittings for water loop	100DN PVC, ~20m	2 lots
13	Tachometer for motor/pump speed	0-4000RPM. Digital display on Main panel [RPM]	2 lots
14	Vibration meter transduced to the Monitoring panel	Portable Accelerometer: 0-100 [Hz]	2 lots
15	Air chamber	Steel drum damping pressure fluctuations to < 5%.	2 lots

3.2 PV Panel Tester

#	Item	specs	No. off
1	Array Tester: Measures and displays the following I/V characteristics of PV arrays: <ol style="list-style-type: none"> i. Short circuit current ii. Open circuit voltage. iii. Current at max. power iv. Voltage at max. power v. Max. Power vi. Fill factor vii. Array temperature viii. Display of all above parameters. ix. Display normalized I-V and P-V curves. x. Supportive software. 	Current rate: 50A, accuracy:1.5% at 25C. Voltage: 12- 600 V, accuracy: 1.5% at 25C. Data Acquisition System: 16 bit resolution. Peak Watt range: 50-60,000. PV panel temperature Range: 5°C to 60°C. Accuracy +/- 0.2°C.	2 lots
2	Insulation resistance testing	Megger Insulation and Continuity Tester with specs: 4.1Insulation Nominal test voltages 1000 V, 500 V, 250 V (d.c(. 4.2Measuring Range: 10 kΩ - 999 MΩ on all ranges • Test Current on load: 1 mA at min. pass values of insulation (as specified in BS7671, HD 384 and IEC 364)	1 lot
3	Solar PV Electroluminescence Cameras Crack Detection Equipment	1x1.5m test area	1 lot
4	Panel supports (variable dimensions).	Clear surface area: 8mx4.5m (see Fig.2)	1 lot
5	HSE	System should be IEC 61730 Parts I & II, compliant.	

3.3 PV Module Light Simulator

#	Item	specs	No. off
1	<p>The PV simulator provides specified equivalent current - voltage (I-V) characteristics of a PV modules up to 2.0m x 2.0m. The steady-state light is adjusted to the required intensity and is measured by a calibrated reference cell located in the test plane. The unit measures and displays the following module parameters:</p> <ol style="list-style-type: none"> i. Complete I-V curve. ii. Open-circuit voltage, V_{oc}. iii. Short-circuit current, I_{sc}. iv. Maximum power point. v. Equivalent Module efficiency. vi. Fill factor. vii. Equivalent Module temperature, C°. viii. Data and I-V curve corrected to standard conditions. ix. Conforms to IEC 904-9 Class C or Class B. x. Optional alternate thin film reference cell. 	<p>Source: Halogen Dichroic lamps, or equivalent Intensity range: 700 to 1100 W/m^2. Lamp lifetime, typical: 1000 hrs. Illumination Uniformity: 2% over area.</p> <p>Measurement Range: Voltage: 0 - 120 Vdc. Current: 0 - 20 Adc.</p> <p>Accuracy: Voltage: 1% full scale. Current: 1% full scale.</p>	2 lots

3.4 Controllable DC power simulator

#	Item	specs	No. off
1	<p>A DC power supplier, rectifying AC supply from the Grid to simulate a given PV solar supply when the required power exceeds system's load level.</p>	<ol style="list-style-type: none"> i. Max power output: 60kW DC ii. Frequency of AC supply: 50 Hz. iii. Output Voltage and current: Fully controllable. 	2 lots

3.5 Inverter Tester

#	Item	specs	No. off
1	<p>The typical test setup includes the procedures:</p> <ol style="list-style-type: none"> i. Split-phase and three phase testing using the appropriate setups. ii. Inverter DC Performance during voltage and power changes in the DC source. These include: Inverter “DC Off” Delay Test and Irradiance Profile Test. <p>The equipment required for the Solar PV Inverter Test Procedure are:</p> <ol style="list-style-type: none"> 1. Grid simulator (GS): supplies typical actual voltage and frequency deviations. 2. Solar PV Simulator (PVS): Emulates solar PV panel performance. 3. Equipment under test (EUT): Solar PV inverter (1-phase or 3-phase inverter). 4. Load Bank (LB): Real and reactive load variable impedance. 5. Power analyzer (PA): records voltage and current raw data at high sampling rates. iii. Computer (CPU): control the grid simulator and power analyzer. 	1Branded/standard make	1lot

3.6 Weather Monitors

#	Item	specs	No. off
1	<p>Site meteorological conditions monitors, including:</p> <ol style="list-style-type: none"> i. Site irradiance ii. Ambient temperature iii. Wind Speed iv. Wind direction v. Humidity vi. Barometric pressure. <p>Data transmitted to the data center.</p>	<p><u>Sensors:</u> Solar radiation Range 0 to 1200 W/m² .Accuracy +/- 1%. Ambient temperature Range 5°C to 60°C . Accuracy +/- 0.2°C.</p> <p>Communication: Serial port RS-485 2 wire, modbus RTU, SunSpec compliant. Power supply: PV power supply input 10-30 VDC, 50mA.</p>	2 lots

3.7 Portable Measuring Devices

#	Item	specs	No. off
1	LCD Laser Portable thermometer.	Temperature Range 10°C to 150°C . Accuracy +/- 0.2°C.	2 lots
2	Portable Power analyzer: Multi channel Power Analyzer optimized for single and three phase efficiency testing, power and harmonic analysis on AC-DC power supply, LED lighting, UPS Systems, Inverters, power converters and PWM motor drives.	Remote operation, Logging, Application wizards, Efficiency Testing, Result grid, Harmonics chart, waveforms, Trend, Pass/Fail limits, Custom formulas, IEC62301 ED 2 test, MIL-1399 test . Voltage rang 10-600 Vrms Current rang: 0.5 – 200 A Accuracy: 0.04% rdg + 0.04% range Communication ports: USB Host, USB, Ethernet, RS232.	1 lot
3	Portable Wattmeter		
4	Portable digital DC /AC Multi-meter.		
5	Digital non-contacting Tachometer.		

3.8 Demonstrational PV Pump

A complete PV pump is to be provide to serve as:

- i. Test lab commissioning rig
- ii. Demonstrational rig for future customers
- iii. A training system

The provided PV Pump shall be of top quality and shall be supplied with complete catalog and performance documents.

The PV pump system should include the following accessories:

- i. Matching Multi-stage submersible centrifugal pump
- ii. Matching helical rotary pump
- iii. Matching surface centrifugal pump
- iv. Matching floating pump
- v. Matching AC motor.
- vi. Matching DC motor

4 FAST-MOVING SPARE PARTS

The Contractor is required to provide a list of anticipated fast-moving parts, complete with quantity and price.