Section - II

Technical Specifications of Tuiriza
Micro Hydroelectric Project

There shall be 1 nos. 100KW Turbine Generator set generating at 415 volts. The generated power shall be synchronized with grid at L.T. level and stepped up to11kV by 250kVA, 0.415/11kV transformer. The 11kV Power will be transmitted through 6.0 Km 11kV line to the nearest village, ie. Phullen. In the absence of grid, the machine shall be run in isolated mode to feed power to nearby areas.

1. HORIZONTAL CROSS FLOW TYPE HYDRAULIC TURBINE, INLET VALVES, GOVERNING EQUIPMENT AND AUXILIARIES

1.1 Scope

This section of the specifications covers the design, manufacture, tests at works, supply, delivery at site, testing at site and commissioning of 1 no. of Horizontal Cross Flow hydraulic turbine and associated auxiliary and ancillary equipment.

The scope of supply shall include all parts, accessories, and spares etc., which are essential for construction, operation and maintenance of the complete prime mover even though these are not individually or specifically stated or enumerated. The turbine manufacturer shall co-ordinate with the generator supplier so that the generator to be coupled to the turbine is matched in respect of speed, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements.

1.2 Type and Rating

The turbine shall be of the Horizontal Cross Flow suitable for coupling directly to horizontal shaft synchronous generator of nominal rating of 100kW. The direction of rotation shall be clock-wise when viewed from drive end. The rated net head of the turbine shall be **50 m.**

The turbine shall be capable of giving output higher than rated output to match the overload capability of the generator. The turbine shall be designed to give a rated output at rated head and discharge. The turbine shall have adequate capacity commensurate with the 10 % continuous overload capacity of the generators. The turbine would have output higher than the rated output when operating at heads higher than the rated head. The supplier may offer his nearest standard design.

The specific speed of the turbine shall be as per the best modern practice and of proven design and operation.

1.3 OUTPUTS AND EFFICIENCY GUARANTEES AND PENALTIES

1.3.1 Output and Efficiency Guarantees

The rated output of the turbine at rated head shall be stated and guaranteed. The efficiency of the turbine at rated head for 100%, 80% and 60% rated output shall also be guaranteed. These figures shall be applicable for purpose of rejection limits and bid evaluation as defined in following clauses 1.3.2 and 1.7.

1.3.2 Rejection Limit

The purchaser has the right to reject the turbine if the test value of either weighted average efficiency or the rated output is less than the corresponding guaranteed value by 2(two) percent or more after allowing tolerance in computation of efficiency.

1.3.3 Weighted Average Efficiency

The weighted average efficiency of the prototype turbine shall be determined from the field test or model test values of efficiency at rated head in accordance with the following formula for purpose of penalty and rejection limit and bid evaluation. Tμav =k1 x Tμ100 +k2 xTμ80+ k3 x Tμ60 Where Tμav Weighted average efficiency of the turbine, Tμ100, Tμ80 and Tμ60 are efficiencies of turbine at 100%, 80% and 60% rated output at rated head respectively. The value of K_1=0.4, K_2=0.3 and K_3=0.3

1.3.4 Rectification to meet guarantees

The Tenderer shall be given 4 months or mutually agreed time to improve/modify the design of turbine or to carry out rectifications, etc., as may be required so that the guarantees are met in case the tests prove unsuccessful in meeting the guarantees. If the second meeting is also unsuccessful, penalty or rejection of the equipment, as the case may be, shall be applied. However, no delay in the original delivery schedule shall be allowed if the model test results do not meet the guarantees and rectifications are made by the Tenderer thereafter within a period of 4 months or mutually agreed period as stated above.

1.4 Speed Rise and Runaway Speed

The moment of inertia of the unit and the load controller response time shall be so adjusted that the maximum momentary speed rise of the unit shall not exceed 35% of the rated speed at the rated head under any condition of operation. The turbine manufacturer shall coordinate with the generator manufacturer for limiting the speed and pressure rise values. The maximum runaway speed of the unit, under any combination of head and load conditions shall be stated in the tender. The turbine shall be capable of running safely at maximum runaway speed without any damage to its parts for a period of not less than 15 minutes for every such occurrence.

1.5 Noise Level

Maximum noise level resulting from any of the operating conditions shall not exceed 90 db (A) at any place 1.0 m away from operating equipment in the machine hall.

1.6 Stress and Factor of Safety

All parts of turbine shall be designed and constructed to safely withstand the maximum stresses during the normal running and runaway and short circuit conditions, out of phase synchronizing and brake application. The maximum unit stresses of the rotating parts shall not exceed two-thirds of the yield point of the material. For other parts, the factor of safety based on yield point shall not be less than 3 at normal conditions. For over-load and short circuit conditions, a factor of safety of 1.5 on yielding point shall be permitted.

1.7 Bid Evaluation

In the comparison of the tenders; the equalization on account of differences in the efficiencies of various offers will be made on the basis of weighted average efficiency as calculated by the formula given below: Tμav = K1 x Tμ100 + K2 x Tμ80 + K3 x Tμ60 at rated head. Where Tμav = weighted average efficiency and Tμ100, Tμ80, and Tμ60 are efficiencies at100%, 80% and 60% outputs, respectively, at rated head. The highest figures of weighted average efficiency will be the basis for comparison of prices of turbines with lower efficiencies and will be loaded at the

rate of 0.5% of their ex-works prices for each 0.1% difference in weighted average efficiency as compared with the highest weighted average efficiency.

The weighted average efficiency of the turbine will be multiplied by the efficiency of the gear box (if provided) for obtaining overall weighted average efficiency which will be used for bid evaluation.

1.8 Model Test

The rates for model test as per relevant standards may be quoted separately. The purchaser shall have the option to get the model test performed by the Tenderer at an extra cost after the award of the contract. In that event, the manufacture of any part of prototype turbine shall be started only after the efficiency and other guarantees and requirements of the turbine are established and fulfilled on the basis of model tests. In case the Tenderer has already performed model tests on homologous models, the purchaser may, at his discretion, permit the Tenderer to proceed with the manufacturer after approval by the purchaser of the model test report.

The performance of the model tests either afresh or that had been done earlier shall be as per IEC 193 and 193A in all respects. Hydraulic performance tests shall be made at various openings to determine machine characteristics including regimes of safe operations, zones of vibration, etc. These tests shall include determination of capacity, hydraulic thrust, runaway speed, nozzle opening output relationship, etc., and such other details as covered in IEC 193 and 193A. Model tests shall simulate all possible normal operating conditions of the prototype for entire range of heads and loads. The tenderer shall clearly mention the time within which the model tests including manufacture of a new model, if required, will be completed. The delivery schedule given by the tenderer shall be reckoned from the date of approval of model tests or model test report or from the time of permission to proceed with the prototype manufacture. If the model test is already available, this shall be submitted within 1(one) month after the award of the contract if required by the purchaser.

1.9 General Arrangement And Construction

The turbine shall be of horizontal type Cross Flow type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts. The design shall also permit horizontal/vertical movement of runner shaft by an amount sufficient for adjustment of bearings and for clearing the joint at the coupling between the turbine and the generator.

The turbine shall be complete in all respects with the casing, bearings, base frame, runner, shaft, guide vane, valve, cooling system, draft tube, special tools and the turbine instrumentation, control and safety devices etc. designed and constructed in conformity the latest prevailing standards.

1.10 Main Inlet Valve

The main inlet valves of the turbines shall be butterfly valve type suitable for Gross Head and discharge required for over load capacity of the turbine / generator and connecting to the proposed penstock. The valve shall be suitable for all operating conditions of transient and

maximum water hammer. The valves shall be operated by oil pressure/counterweight, so that it is capable of being closed under all emergencies.

1.10 Electronic Load Controller

The turbine shall be equipped with Electronic Load Controller (ELC) of suitable capacity for use in isolated as well as grid synchronized mode of operations. The system should include self test diagnostic circuits and programs, error handling routines, alarm messages handling and event logging.

1.11 Shop Assembly and Tests

The following assemblies and tests shall be carried out on the turbines and associated equipment at the manufacturer's works before dispatch in the presence of the purchaser's representatives if desired by the purchaser and test certificates shall be submitted whether or not the tests were witnessed by the purchaser.

i) One turbine, manufactured first, shall be assembled in the shop to the extent possible.
ii) Static and dynamic balancing of runners.
iii) Hydrostatic testing at 1.5 times the maximum working pressure including water hammer for not less than 15 minutes for the main inlet valve, spiral case, servomotors, etc.
iv) Non-destructive testing of welds.
v) Performance tests for individual auxiliary equipment.
vi) Complete assembly and operational tests of governors.
vii) Assembly of spiral case and draft tube liner.
viii) All motors/pumps/compressors, etc., shall be tested as per relevant Indian or other standards.

1.12 Field Acceptance Tests

The turbines shall be tested at site for establishing fulfillment of guarantees in respect of turbine output and efficiencies including weighted average efficiency. The tests shall be carried out as per IEC 41 for Field Acceptance Tests of hydraulic turbines.

The arrangements for these tests will be made, including the testing devices, by the Tenderer.

1.13 Site Testing and Commissioning

The Tenderer shall carry out the commissioning tests in accordance with IEC 545. The turbine, after continuous operation during the trial operation shall be free from problems of leakages, overheating, failure, damage etc. The Tenderer shall depute experts in testing and commissioning of turbine, load controller and associated equipments for erection, testing and commissioning of these.

1.14 Tender Drawings

The following drawings shall be furnished by the tenderer for vetting and approval:

a) Drawings of the main cross section of the turbine showing the various components, parts/assemblies of the turbine to the extent possible.

b) Layout drawings of the power house showing the overall dimensions and layout of turbines, etc., clearly indicating details of turbine foundation, unit spacing dimensions of casing, draft tube and all important elevations.
c) Schematic drawings of piping system, control system and instrumentation.
d) Physical and schematic drawings and descriptive literature on the ELC and ELC mechanism.
e) Charts/curve showing performances and characteristic of the turbine
f) A list of tests to be performed at site.
g) A complete list of equipments auxiliaries, etc. covered in the quotations.
h) Model Test Report
i) Quality Assurance Plan

2. ALTERNATING CURRENT GENERATORS, EXCITERS, VOLTAGE REGULATORS AND ACCESSORIES

2.1 Scope

This section of the specifications covers the design, manufacture, test at works, supply, delivery at site, testing at site and commissioning of 1 no. of Horizontal AC generator complete with excitation system, voltage regulating equipment, neutral grounding and generator terminal equipments including CTs. PTs, (as per protection schemes) surge protection equipment, etc. and auxiliaries.

The generator manufacturer shall co-ordinate with the turbine supplier so that the generators to be coupled to the turbine is matched in respect of speed direction of rotation, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements

2.2 Type and Rating

The generator shall be designed and manufactured on the basis of following requirement

i)	Number required	one set
ii)	Type	Horizontal shaft, water wheel driven, alternating current synchronous generator
iii)	Rated output	100kW
iv)	Rated kVA	125
v)	Power factor	0.8 lagging
vi)	Frequency	50 Hz
vii)	No. of phase	3
viii)	Rated terminal voltage between the phases	0.415 kV
ix)	Range of voltage with which rated output	$\pm$ 10 percent must be available
x)	Range of frequency variation	$\pm$ 3 percent (48.5 Hz – 51.5.Hz)
xi)	Rated speed	to be given by manufacturer.
xii)	Direction of rotation	In accordance with the turbine
xiii)	Runaway speed	To co-ordinate with turbine manufacture
xiv)	Short circuit ratio	Not less than 0.8
xv)	Moment of inertia at the whole generating unit GD^2	Not less than 1
xvi)	Stator-winding connection	Star (Y)
xvii)	Ratio of quadrature axis sub transient reactance to direct axis sub transient reactance x^nq/x^nd	Less than 1.25
xviii)	Generator earthing	Star point solidly earthed
xix)	Cooling water temperature	30 degree Celsius

The generator shall be capable of delivering maximum continuous output of 110% of the rated output at rated power factor. The tenderer may offer his nearest standard. The generator will be connected to the turbine directly or through speed increaser which will be supplied by the turbine supplier. All generator terminals shall be brought out of the stator frame for insertion of current transformer for protection, metering and surge protection apparatus. The generator

neutral shall be grounded suitably and the generators shall be designed to safely withstand any mechanical/magnetic stresses resulting from either a three phase or a single phase fault.

Each generator shall comply in all respects with the requirement of the latest issue of Indian Standard IS:4722 except where specified otherwise.

2.3 Speed Rise and Runaway Speed

The moment of inertia of the generator together with the moment of inertia of the turbine and flywheel (if any) shall be such that the maximum momentary speed rise on full load rejection shall not exceed 35 % of the rated speed. The generator manufacturer shall co-ordinate with the turbine manufacturer to limit the speed rise to this value.

Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at the maximum runaway speed. The runaway speed test shall be considered successfully if after undergoing the test 'no injury' is apparent. The runaway speed test may be carried out at site for which the purchaser would provide suitable foundations that will withstand the test.

2.4 Noise Level

The noise level shall not exceed 90 db (A) when measured at a distance of 1m from any component of the generator.

2.5 Insulation and Temperature Rise

Insulation shall be provided as follows:

i) Stator winding material corresponding to class F.
ii) Rotor winding material corresponding to class F.

The generator shall be capable of delivering rated output continuously at any voltage and frequency in the operating range at rated power factor without exceeding the following values of temperature rise over ambient temperature (30^oC)

(a) Stator winding	60^o C
(b) Rotor winding	60^o C
Stator Core	55^o C

The maximum temperature rise when the generator is delivering maximum output corresponding to continuous overload capacity for conditions stated above shall not exceed 60^oC for both stator and rotor windings.

2.6 Efficiency and Output Guarantees

Within the limits of temperature rise specified above, the rated continuous output of the generator shall be guaranteed under penalty with a rejection limit of minus 2% for the rated generator terminal conditions. The weighted average efficiency of the generator shall be guaranteed under penalty with a rejection limit of minus 2%. The efficiencies shall be determined by the summation of losses method as specified in latest Indian Standard IS:4889.

For any shortfall in the test value of output and weighted average efficiency (as determined below) from the guaranteed figures, the penalty shall be at the rate of 5% of the ex-works value of generator per generator for every 1% by which the test figure is less than the guaranteed figure. The weighted average efficiency = 0.40 x efficiency at full load + 0.30 x efficiency at 80% full load + 0.30 x efficiency at 60% full load. The penalty on account of output and efficiency shall be computed separately and the total amount of penalty shall be the sum of the two. The ceiling on the total amount of penalty on account of shortfall in the weighted average efficiency and output will be 10% of the total unit price of the generators.

No tolerance shall be permitted over test figures of output. Tolerance in determination of efficiency shall be as per relevant Indian Standard.

2.7 Bid Evaluation

For the purpose of comparison of tenders, the equalization on account of differences in the weighted average efficiencies between various offers will be made on the same basis as indicated for penalties, i.e., the prices of generators with lower efficiencies will be loaded at the rate of 0.5% of x-work price each 0.10% (one tenth) difference in weighted average efficiency as compared with the highest weighted average efficiency.

2.8 Structural Details

2.8.1 Stator

The Stator frame, core, windings etc. shall conform to the latest standards available required to meet the desired specifications.

2.8.2 Rotor

The rotor shaft, poles, current carrying leads, bearings etc. shall conform to the latest standards available required to meet the desired specifications.

2.9 Fire Protection For Generator (Optional)

An automatic carbon dioxide fire protection system complete with CO2 cylinders, ring headers, discharge nozzles, temp. detectors etc., shall be provided as a common system for all the generators. The temperature detectors shall be of the rate of the rise of temperature type. Automatic control shall be arranged to discharge CO2 into the generator in the event of operation of temperature detector or of the differential relay of the generator (if provided). The system shall be complete with manual operation arrangement to release CO2 and with all necessary pipes, fittings, directional valves, etc.

2.10 Oil And Grease

The tenderer shall indicate this requirement and give his recommendations with detailed specifications regarding type of oil/grease to be used for lubrication of generator bearings. The generator and turbine manufacturers shall cooperate to ensure that their recommendations regarding oil are identical. The first filling of oil with 20% extra shall be supplied along with the generator

2.11 The Flywheel

A separate flywheel of ample dimensions shall be supplied in case the required moment of inertia for limiting the speed rise/runaway speeds in case not available from the generator rotor (through the speed increaser, if envisaged). Necessary provision for receiving the piston of the brake cylinder on application of brakes shall be made in the flywheel.

2.12 Excitation System

2.12.1 General

The excitation system shall be of brushless type.

2.12.2 Automatic Voltage Regulator (If Not Already Included In the Excitation System)

An automatic voltage regulator, complete with an enclosed master element, voltage adjusting rheostat, contactors, etc., shall be provided with each generator for the automatic control of the generator exciter. The voltage regulator shall be anti-hunting. The voltage regulator shall be capable of maintaining the generator terminal voltage at and pre-set value and at the same time sharing the reactive kVA of the load between the two similar units.

The voltage regulator shall be sensitive to the charge of plus or minus 0.5 (one half)% 0f normal voltage (average of three phases) of the generator when operating under steady load conditions for any load or excitation within operating range and shall initiate corrective action without hunting.

After the initial maximum voltage following any load rejection up to 110 (One hundred and ten)% of rated load, the automatic voltage regulator shall restore the terminal voltage to a value not more than 5(five)% above or below the voltage being held before the load rejection and shall maintain the voltage within these limits throughout the period of generator overspeed. The voltage regulator shall be provided with cross-current compensating devices for parallel operation of generators.

A voltage adjusting rheostat suitable for manual and also for motor operation by remote control shall be furnished with each voltage regulator equipment. The range of the voltage control shall extend from 90 (ninety)% to 110 (One hundred and Ten)% of rated voltage of generator.

2.15 Current Transformers

The current transformer will be epoxy cast, dry type unit conforming IS:2705 and accuracy class as per CEA regulations. The current transformer shall be designed to withstand the thermal and magnetic stresses resulting from the maximum short circuit current.

The current transformers should be suitable for metering and protection.

2.16 Surge Arrestors

The lightning arrestors shall be heavy duty indoor station class non-linear resistor type suitable for repeated operation to limit voltage surges on alternating current power circuits and to interrupt power follow current. The arrestors shall conform to IS:3070 (latest edition)Part-I. The nominal discharge current of lightning arrestor shall not be less than 5KA.

2.17 Surge Capacitors

The surge capacitors shall conform to the latest edition of IS:2834 and shall be rated 0.25 microfarad. The capacitors shall be connected in parallel with lightning arrestors and shall be provided with a built-in discharge resistor. The capacitor shall be suitable for indoor mounting.

2.18 Unit Control Board And Generator Instrumentation, Control And Protection

The generator supplier shall supply all equipment and devices for control, instrumentation and safety relating to the generator. These together with the equipment supplied by the turbine supplier shall constitute a complete and coordinated set of instruments, gauges, and control and safety devices for control of the units during normal running and in emergencies. indicating instruments, gauges, control and safety devices will be mounted on the unit control board to be supplied by the generator supplier. The turbine supplier shall supply necessary loose items for mounting on the unit control board. The generator manufacturer shall fully coordinate with the manufacturer of turbine to ensure a neat and functional arrangement of the cubicles. The generator manufacturer may increase/decrease items according to requirements to suit the type and design and also for proper and satisfactory operation of the units. The alarm and annunciation panel with all necessary annunciation relays, aux relays, alarm bell, terminal bolts etc., and adequate number of alarm annunciation fascia windows for both turbine and generator shall be provided. The generator manufacturer shall fully co-ordinate with the turbine manufacturer in this regard.

Numerical relays should be provided for overall generator protection consisting of:-

a) Over-current and earth fault relay (50/51)
b) Rotor earth fault protection single stage (64 R)
c) Stator earth fault protection (64 G)
d) Over voltage protection (59)
e) Field failure protection (40)
f) Negative phase sequence (46)
g) Reverse Power Protection (32)
h) Over speed/frequency protections (81)

The following meters should be provided:-

a)	Ammeter	– 3 nos.
b)	Voltmeter with selector switch	– 1 no.
c)	Kilowatt meter	– 1 no.
d)	Frequency meter	– 1 no.
e)	Power factor meter	– 1 no.
f)	Trivector meter	– 1 no.

Automatic synchronizer must be provided in the Unit Control Board to work in conjunction with the ELC.

2.19 Tests

The first generator shall be completely assembled at works and types tests as specified below shall be conducted on the assembled unit and auxiliaries as per the latest edition of IS:4722.

2.19.1 Type Test on First Generator

a) Temperature rise test.
b) Dielectric test.
c) Efficiency test.
d) Excess current test.
e) Runaway speed test.
f) Moment of inertia of rotating parts (by mutual agreement between the purchaser and the Tenderer)
g) Wave form
h) Determination of characteristic:
i) Reactances – Synchronous, transient, sub transient, negative phase sequence and zero phase sequence.
ii) Rated current, zero power factor lagging saturation curve.
iii) No load and short circuit saturation curve.

2.19.2 Routine Tests on all the Generators

a) High voltage test on stator coils and stator sections and on assembled stator.
b) High voltage test on field coils and poles.
c) Insulation resistance tests.
d) Impedance and voltage test on field coils.
e) Accuracy test for RTDs and dial type thermometers.
f) Hydraulic tests on oil, and air coolers.

2.19.3 Tests on Exciters and Regulating Equipment (For Rotating Exciters)

a) High voltage test.
b) Temperature rise test.
c) Measurement of resistances.
d) Measurement of insulation resistance.
e) Regulation test.
f) Commutation test.
g) Excitation response ratio.

2.19.4 Test on other equipment like CTs, PTs, LAs shall comply with the routine tests, etc., as per relevant standards.

Test report for all type tests on the generator, CTs, PTs, etc., carried out on similar equipment already supplied shall be furnished for approval.

2.22 Drawings

In addition to the drawings called for, the following drawings and data shall be submitted with the tender.

The drawings containing all the information required for construction of generator foundation shall be supplied within 45 calendar days of the placement of purchase order:

i) The general arrangement and overall dimensions of the generators, exciters (where applicable) and bearings, and showing positions of main and neutral terminals.
ii) Description of lubrication system along with drawings.

iii) Physical and schematic drawings of excitation system and AVR along with descriptive literature.
iv) Graphs showing predicted characteristic of the generator.
v) Generator layout drawings showing overall dimensions and layout of all ducts, cables, piping, relative positions of auxiliaries, etc.