Assignment/Project Title: Energy and Water Audit for Shimla Bulk Water Source to Storage System
Placement of assignment: India
Assignment Duration: 5 months
Assignment Type: Firm

A. PROJECT BACKGROUND AND OBJECTIVES

The Government of India (GoI) has made significant investments in the WSS sector across urban and rural areas and has shown continuous commitment through bringing in sector reforms and enhanced financial allocations to the sector.

Shimla is the capital city of the state of Himachal Pradesh (HP). The state of HP has a population of 7 million, with many perennial rivers flowing in the state, and hydroelectric power projects, tourism, and agriculture as major contributors to the state’s economy. Shimla is situated south of river Sutlej at an average altitude of 2,130 m above sea level. The administrative responsibilities reside with the Shimla Municipal Corporation (SMC), an elected body comprising 27 councilors and 25 wards. Today, Shimla city is rapidly expanding, with its economy largely driven by tourism as well as horticulture, trade, education and health services. Current population of the SMC area is about 180,000 plus an additional floating population of about 75,000. The population in Greater Shimla area is expected to rapidly increase from existing 0.3 million to 0.5 million by 2050. In addition, there is a huge tourist population all year round, but mostly adding to WSS demand during the peak summer season.

Water Supply and Sanitation Services in Shimla
Piped water is the main source of supply to households and commercial establishments, other than tankers which are being increasingly used to meet the growing water requirements. Currently, 79% population has access to piped water supply, with 22,461 domestic and 7,501 commercial service connections. Water supply is provided for 1-2 hours, once in three days in the main city area, and lesser duration in the peri-urban areas. The piped water system in Shimla is more than 100 years old and consists of seven water supply schemes. The design capacity of the water supply schemes, drawing water from various rivulets and tributaries, is 65 MLD.

The cost of water services is high due to the need to pump water 1,400 meters up from its source. The actual supply has depleted to 40 MLD due to (a) reduction in water yield at the sources; (b) competing irrigation demands; and (c) deterioration in water quality. The water demand is expected to rise from an estimated 62 MLD at present to 106 MLD in 2050, based on a 30-year projection for Greater Shimla area. NRW is estimated at 40-50%, mainly due to the very old water supply system.

Until 2016, the water supply and sanitation (WSS) services in the Greater Shimla Area were handled by three units with fragmented responsibilities: (i) the Shimla circle of the IPH department, responsible for providing treated bulk water and for treating sewage for the SMC area; (ii) the WSS department of the SMC, responsible for distribution of treated water and collection of waste water within SMC limits; and (iii) a peri-urban division of IPH, responsible for WSS in the areas outside the SMC limits. In 2016, the GoHP established the Greater Shimla Water Supply and Sewerage Circle (GSWSSC), to reduce the fragmentation of

1 Greater Shimla Area includes the SMC area and the Shimla peri-urban area comprising 30-40 Panchayats.
responsibilities. GSWSCC was established as a ‘ring-fenced’ department within the SMC through a Government Order with the responsibility for water supply (bulk and distribution) and sanitation. Staff has been seconded by IPH to SWSSD. A separate bank account has been created for SWSSD. A Memorandum of Understanding (MOU) is being drafted to formalize and to detail the institutional arrangements and roles and responsibilities. These changes will introduce a substantial degree of autonomy and accountability for WSS operations.

B. OBJECTIVES OF THE TOR

The overall objective of this assignment is to conduct a detailed energy and water audit of the Shimla water supply system from the water sources to the main reservoir to identify, assess and recommend opportunities for improving energy efficiency and reducing NRW.

C. SCOPE OF WORK

The Consultants will apply its know-how and expertise in energy and water audits to create a robust baseline of water and energy use, define electricity and water-use patterns, identify and assess potential for optimization of electricity use patterns, create a list of specific water and energy savings measures, define the opportunities for a routine demand-response initiative and potential for generating power from sewage discharge, and identify the investment requirements and project paybacks.

The specific tasks to be performed by the Consultants are listed below:

- **Task 1:** Creation of baseline of water and energy use throughout the bulk and end-use consumption
- **Task 2:** Field measurements of electrical use systems, water leakages, electricity use-patterns
- **Task 3:** Develop water and energy use optimization recommendations including list of specific technical interventions (retrofits and replacements)
- **Task 4:** Analysis of alternate energy generation potential including (i) (hydro) electricity from treated sewage discharged from high elevation points, (ii) solar PV at the key water and wastewater treatment sites and (iii) energy recovery from waste water treatment sludge
- **Task 5:** Final Report and recommendations to GSWSCC for implementation.

Detailed descriptions of the required tasks are provided below:

**Inception Mission**

The Consultant shall conduct an Inception Mission to meet with the stakeholders, identify data sources, review all project tasks and prepare a detailed implementation plan. The Consultant shall submit a detailed Inception Report at the end of the Inception Mission.

**Task 1: Create baseline of water and energy use throughout the bulk and end-use consumption**

The baseline development task shall include following sub-tasks:

- Physical mapping converted as 3-dimensional GIS maps of water sources, elevations, pumping heads, reported quantum of water pumped, locations of water pumping stations, elevations, lengths and documenting the population served through the current networks
• Prepare single line/block diagrams of the water sources, pumping stations, and reservoirs as well as discharge points of treated wastewater.

• The reservoir levels in different seasons should be reported by capturing data from the log sheets maintained at the water pumping stations and at any master control center.

• Create maps and datasheets that include bulk water network pipelines, material of constructions, line sizes, pressure releasing systems, bends, valves, isolation systems including MOC and makes, vintages – all of above should be mapped for the entire network including bulk and end-use water pumping system and with a target of creating an effective SCADA/similar monitoring systems.

• Electricity consumption at the bulk and booster water system components tracking the time-of-use of electricity, outages, transformer burn-out frequencies, sub-distribution and high-voltage network feeder-level power quality, voltage levels, frequencies, harmonics, load variations. Though all the electrical parameters information for the past one year are not available with the electricity and water departments, the Consultant is encouraged to capture the instantaneous data by installing electricity meters at the low-voltage levels and should leave the meters at the site for a period of one year.

• A representative sample of pumps should include metering system to capture data of water pumping operations (pumping hours, quantity of water pumped, key electrical parameters etc.)

• Consultant is also expected to design a small Network Operating Centre (NOC) to push the electricity metering data at the major sub-stations on a continuous basis using GPS/GPRS communication devices using open communication protocols that are vendor-agnostic. When implemented as an option, the NOC design should have the capability to give a remote access to The World Bank team and its client for a period of one year from the date of initiation of this activity when take up. Consultant shall make sure that the costing for the GPS/GPRS data transfer capability is covered for at least a year in the design element, after which the Consultant shall transfer the knowledge to the GSWSSC.

• Electricity bills paid by the GSWSSC and its allied entities shall be captured and presented as a detailed billing analysis, which should essentially include demand charges paid, time-of-use of pumping energy, penalties paid by GSWSSC and identification of measures to stagger the load shapes and to improve the power factors.

• Trace the water distribution from the main reservoir at Sanjouli to create water balance.

• Related to the leakage detection, the Consultant should capture relevant details of the water quantity measurements from the pumping system sites up to the main storage facilities.

**Task 2: Field measurements of pumping assets, water leakages, electricity use-patterns and analysis**

Based on the findings of the baseline assessments, the Consultant shall create a detailed activity plan to carry out the needed field measurements. The Consultant shall create a robust profiling of the energy and water use in the water sourcing, pumping and storage. The field measurements shall also develop an understanding of the seasonal variations in the energy and water consumption considering peak winter, peak summer, and visitor seasons. The Consultant is expected to use calibrated meters to capture energy and water consumption. A detailed list of all the instruments owned and to be hired to carry out the field measurements should be furnished by the Consultant.

The proposed study places substantial emphasis on creating linkages between water and energy use to deliver the water with clear reporting of benchmarks and associated costs. As such, the study requires a focus on the time of use of water and energy resources and seasonal variations. It should also be noted that...
the proposed activity requires installation of metering systems at key locations within the supply network and continuous data collection throughout the data collection period spread over 3 months.

The specific field measurement requirements are listed below. The Consultant shall:

- Evaluate the efficiency levels of all the pumping operations tagging the bulk and booster pumping systems by actual field measurements, creating a detailed list of inventories, evaluate individual pump performance, pumping network performance, pressure profiles within the pumping system intake and discharge locations, and locations of booster pumping systems.

- Install metering systems at the representative pumping stations at the bus-bars or at the individual pumping station levels to ensure continuous data logging takes place at the key pumping locations.

- Ensure all the power measurements carried out using power analyzers capture all key parameters such as phase voltages, current drawn, energy, instantaneous energy, power quality and harmonic distortions.

- Capture sub-station and transformer-level power quality analysis and efficiency levels of the transformers analyzing transformer losses, failure rates, and power quality improvement opportunities.

- Conduct flow measurements using ultrasonic or any other appropriate flow measurement techniques.

- Compare operational parameters of the pumps with the design efficiency curves, component (motors and pumps separately), and system efficiency.

- Carry out a detailed water and energy use modelling up to the reservoirs using standard pressure and flow assessment software simulating field conditions within the relevant network libraries. This analysis shall be carried out for both bulk and network/end-use level. All the analysis shall be presented using key performance parameters such as water flow expressed in m³/hr and its comparison with the specific energy consumption expressed as m³/kWh or m³/kVA, pump and header discharge pressures compared with the design values.

- Conduct simulated and real-time diagnostics relevant to the water pumping operations within the pumping stations and throughout the network.

- Develop detailed analysis of energy use throughout the bulk and booster systems including historical billing analysis.

**Task 3: Develop water and energy use benchmarks and optimization recommendations including list of specific technical interventions (retrofits and replacements)**

Based on the detailed energy and water use analysis carried out as a part of Tasks 1 and 2, the Consultant is expected to create detailed recommendations that focus on retrofits, replacements and operational aspects. Specific sub-tasks are included below.

- Consultant shall evaluate the field measurements, results of the simulations of current bulk water supply configurations with an objective of improving water pumping, treatment and distribution efficiencies.

- Create scenarios using modelling techniques to show the possible lowest energy footprint and
lowest water leakages with an emphasis on making water availability for 24X7

- Present specific pumps, motors, pumping system and piping network retrofit and replacement options calculating the payback periods using base tariffs, demand charges capturing cost of retrofits
- Present water leakage reduction options including possible replacements of the old piping networks
- Present energy use optimization options considering staggering of loads using the network analytics considering creating additional storage to stagger the loads and to stagger the pumping operations with a possible design of demand response initiative to be jointly rolled out by GSWSSC in partnership with the electricity distribution licensee
- Develop basic engineering designs package for water pumping system from Gumma to Craignano reservoir, as though currently the system does not exist, to develop an understanding of energy use benchmarks to be used by GSWSSC. Output from this activity may be used by GSWSSC to redesign and commission an entirely new system to optimize energy use and to reduce leakages in the bulk water supply network

Task 4: Analysis of alternate energy generation potential including (hydro) electricity from treated sewage discharged from high elevation points and solar PV at the key water and wastewater treatment sites

Three alternate energy generation options are possible to be implemented at the SWWSC sites. These are hydropower generation from the treated water disposal, solar-PV generation using the rooftops available at the water pumping and disposal stations, and energy recovery from waste water treatment sludge. (1) The Consultant shall study the current sewage treatment and discharge system including the gradient available to develop a piping system and establishment of a turbine and powerhouse. The Consultant shall test the treated sewage samples for pH, suspended solids, residual organics, dissolved solids and fluid viscosity to determine suitable material of construction/lining requirements for the piping network. This information shall be used to assess and recommend the best options generate electricity. In addition to the assessment of electricity generation potential, the Consultant shall develop a basic engineering package for developing sumps, piping systems, isolation valves, surge controls, powerhouse, substation controls and power evacuation points. The report developed by the Consultant should be elaborate enough to take an investment decision; (2) The Consultant shall capture data related to the size of rooftops available at all pumping stations and wastewater treatment sites. Based on the orientation, strength of existing structures and insolation factors, the Consultants shall develop a short prefeasibility report to project solar power generation, infrastructure costs and paybacks at the current tariffs; and (3) The Consultant shall carry out a pre-feasibility of energy recovery sludge disposed off after post treatment of city waste water. Analysis shall include developing scenarios of power generation using combustion techniques, use of anaerobic digestors and running engines on the off-gases and any other advanced energy recovery options that are available for varying levels of moisture content of the sludges, their solid consistencies, available volatile organics and fixed carbon, also dweling on the disposal/recycling of residual ash and/or solids. The Consultant should create a short prefeasibility report assessing technologies, operations & maintenance requirements and cost-economics.
**Task 5: Final report and recommendations**

Consultant is required to submit a final report that includes the following:

- Technical specifications and datasheets referencing relevant Indian codes and standards
- List of vendors of suggested equipment
- Definition of measures for improving energy efficiency and reducing NRW
- Options for implementing demand-response

**Project timelines and deliverables**

It is expected that the project activity will last for 5 months. The deliverables and completion dates for are indicated in Table 1 below.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Description</th>
<th>Deliverable</th>
<th>Completion date (from inception)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inception Mission</td>
<td>Inception Report</td>
<td>One month</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Creation of baseline of water and energy use throughout the bulk water pumping up to storage facility</td>
<td>Draft Report on Baseline</td>
<td>Two months</td>
</tr>
<tr>
<td>2</td>
<td>Field measurements of pumping assets, water leakages, electricity use-patterns and analysis</td>
<td>Draft Report on measurements</td>
<td>Three months</td>
</tr>
<tr>
<td>3</td>
<td>Develop water and energy use optimization recommendations including list of specific technical interventions (retrofits and replacements), energy cost benchmarks and basic engineering design package from Gumma to Craignano</td>
<td>Included in Final Report</td>
<td>Three and half months</td>
</tr>
<tr>
<td>4</td>
<td>Prefeasibility reports related to the three alternate energy generation options listed above</td>
<td>Included in Final Report</td>
<td>Three and half months</td>
</tr>
<tr>
<td>5</td>
<td>Preparation of Final Report and Bid Package to be used by GSWSC to implement the recommendations</td>
<td>Draft Final Report, Final Report</td>
<td>Four months, Five months</td>
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**D. SPECIAL TERMS AND CONDITIONS AND SELECTION CRITERIA**

**Duration of Assignment**

The contract is expected to commence on XXXX and conclude on XXXXXX.

**Reporting**

The Consultant is responsible for all logistics including, but not limited to, transport, lodging, supplies, translation/interpretation, telephones, computers, and so forth.

**Payment Schedule**

The assignment will be remunerated on a lump sum basis as per the norms and procedures of the World Bank. Payment will be linked to the following deliverables (specified in the Scope of Work), after being accepted by the World Bank to its satisfaction:
• Contract Signing: 10% of contract value
• Inception Report: 10% of contract value
• Draft Report on Measurements: 20% of contract value
• Draft Final Report: 30% of contract value
• Final Report and Bid Package: 30% of contract value

The payment schedule will be on approval of the deliverables.

**Required Firm Qualifications and Experiences**

The Consultant must demonstrate experience in:

• Conducting investment-grade energy audits for water supply and distribution systems
• Understanding of design and roll-out of NRW assessments for bulk and retail water pumping, storage and distribution systems
• Expertise in using GIS mapping tools and their applications in the water distribution systems
• Flow measurements for bulk water supply and distribution networks and creation of water and energy balance
• Understanding of electricity distribution, installation of smart meters at LT and HT levels as needed, finalization of telemetry to capture data from individual meters on to central servers and creating appropriate dashboards
• Experience in carrying out prefeasibility of hydroelectric system design, engineering and costing with raw and/or treated water, assessment of solar PV installations and energy generation and assessment of waste to energy plants using treatment sludges

**Bid Submission Requirements**

Bidders should submit their proposal that include following information:

• Introduction to Consultant Firm (or Consultant Team)
• Consultant’s understanding of the requirements of scope of work
• Detailed Approach and Methodology highlighting plan to implement the stated tasks, concurrency of water/energy audits, methodology to capture data at a suitable Network Operating Centers and software formats used to ensure data is available in open formats
• List of all the instruments to be used in the field measurements (owned or hired with the class of accuracies), metering devises to be used with error boundaries, telemetry services that would be deployed in the field to conduct NRW and energy audit studies
• Detailed resumes of the Team Leader, Lead Experts for NRW and Energy Auditing studies, supporting technical staff conducting field measurements, GIS expert, instrumentation/metering experts, financial analysts, procurement experts capable of developing comprehensive technical specifications
• Detailed week-wise timeline of all sub-activities identifying critical paths in the implementation of NRW and energy audits
• Financial bid that establishes time spent by experts in the field, home-offices, travel and other incidentals, direct procurement of meters and telemetry services for the project period and for a period of at least one year
Annex - Preliminary Snapshot of Shimla Water Supply and Sanitation Infrastructure

The Shimla Water Supply and Sanitation infrastructure has been developed over a period of 80 years to cater to the growing end-uses. Shimla has a population of 200,000 permanent residents with floating tourist population that varies by seasons. SMC has been able to supply approximately 110 lpcd (litres per capita per day) water to the residents albeit intermittently. Schematic layout of the Shimla Water Supply scheme, up to the main storage system, is presented in the attached figure.

System network:

The City of Shimla primarily gets water supplied from tributaries of river Sutlej and Giri. Out of the 7 pumping stations (Gumma old and new, Nauti Khad, Giri, Chair, Jagroti/Cherot and Ashwani Khad), two sources Gumma (old and new) and Giri cater to over 90% of the water used. Out of the total 45 MLD of water supplied to the residents of SMC, over 36 MLD water is supplied from Gumma and Giri pumping stations. Gumma pumping station comprises of two sub-systems Gumma Old and Gumma New, both having their own water treatment plants. Nautikhad pumping station too is situated in the same region, drawing water from same source. Gumma Old, New and Nauti Khad pumping stations were gradually developed over the past 80 years. Giri pumping station is comparatively new, which was developed in 2006-07 period. Four pumping stations Gumma New, Nauti Khad and Giri are connected to a main reservoir at Sanjauli through staged pumping at Dabrala, Nauti Khad II and Bekhalti. Gumma Old pumping system is directly connected to the Sanjauli reservoir. Chair water pumping system caters to the end-use requirements of Kufri region. Cherot pumping system taps water from a spring closer to the station and caters to the Dhali region. Dhali reservoir has a provision to divert water to Sanjauli reservoir should there be a need to do so. In the recent past, the Jagroti pumping system downstream of Cherot was discontinued with the jaundice epidemic that occurred in 2015. Ashwani Khad pumping station caters to the Kasumpti region. Preliminary details of the inventory of pumping machinery, average water pumped per day, reservoir capacities and annual energy charges paid by the pumping station sites have been included in the figure above.

Electricity billing

All the pumping stations referred in the block diagram draw electricity from the HP Sate Electricity Board (HPSEB). Electricity bills are generated for all the stations and settled by the HP Irrigation and Public Health Department or by the Shimla Municipal Corporation. According to the HP Electricity Regulatory Commission’s (HPERC) Mid-Term Performance Review Order – 3rd MYT Control Period (FY15-Fy19), released on April 17, 2017, the water pumping category defined as “Irrigation and Drinking Water Pumping Supply (IDWPS)”. All the pumping stations are characterized as High Tension connections. Electricity bills for all the pumping stations follow specific charges as follows: (i) Demand charge paid as INR/kVA/month, which is currently INR 400/kVA/month determined as actual maximum recorded demand in a month in any 30 minute interval or 90% of the contract demand, (ii) Energy charge of INR 4.45/kWh for HT or INR 4.10/kWh for EHT, (iii) additional Peak Load Charge (PLC) of INR 100/kVA/month charged for average demand during peak load hours for the billing month, calculated as kVA dividing total kVArh consumption during peak load hours of the month by 105 and peak-time energy charge of INR 6.20/kWh for HT and INR 6.00/kWh for EHT; (iv) Night time concession of INR 0.40/kVAh for June-August and INR 0.20/kVAh for rest of the months; (v) Power Factor Surcharge of 10% on the amount of energy charges in conditions where the power factor is lower than 90%. Consultants, as defined in the detailed Terms of Reference, are required to suggest changes in the pumping system operations to reduce the monthly fixed and variable costs incurred by GSWSSC.