DETAILED DESCRIPTION OF PROJECT OUTPUTS

A. Introduction

1. Ceylon Electricity Board (CEB) will develop a 100 megawatt (MW) wind park to be constructed on the southern coast of Mannar Island in the Northern Province of Sri Lanka (Figure 1). Mannar Island is one of the five divisional secretary divisions of the Mannar district. The island has a land area of about 130 square kilometers (km^2) and is almost entirely surrounded by sea. Its topography is characterised by an almost flat sandy terrain, gradually elevating towards the middle of the island up to about 8 meters above the mean sea level. The island's ecological features are characterised by mangroves, lagoon, mud flats, home gardens, coconut plantations, scrublands and natural Palmyra stands.

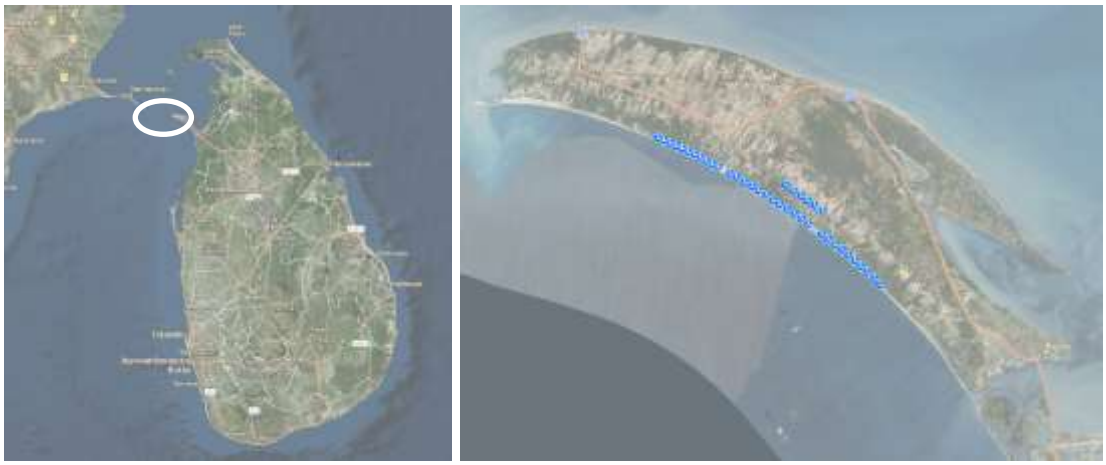

Figure 1: Mannar Island

2. To develop the wind park, the Government of Sri Lanka and CEB requested a loan from the Asian Development Bank (ADB) to finance the Wind Power Generation Project (the project).

3. The project consists of the following outputs:

(i) Output 1: Wind power generation capacity increased:

  (a) 100 MW wind farm constructed in Mannar Island of the Northern Province;
  (b) Wind park infrastructure developed: This involves construction of wind park's internal medium voltage infrastructure, internal cabling, access roads and other arrangements; and
  (c) A renewable energy dispatch control center established: This involves establishing a dedicated renewable energy dispatch control center to forecast, control and manage intermittent 100 MW wind power generation;

(ii) Output 2: 150 megavolt-ampere reactive (MVAr) reactors installed; and

(iii) Output 3: Capacity of CEB in project engineering design review and supervision strengthened.

B. Wind Power Generation Increased

4. This output consists of three subcomponents: (i) 100 MW wind farm constructed in Mannar Island of the Northern Province; (ii) wind park infrastructure developed; and (iii) a renewable energy dispatch control center established.

5. CEB will select a contractor based on an international competitive bidding process to construct the 100 MW wind park on a turnkey basis under an Engineering, Procurement and Construction (EPC) contract. The contract will consist of the following parts:

(i) Engineering design, procurement and installation of a layout of wind turbines, each of which includes rotor, nacelle, tower, and associated equipment. Bidders will be asked to submit a wind turbine layout that makes optimal use of available wind turbine locations to achieve a capacity of 100 MW. A selected EPC contractor will be required to ensure that the final turbine layout complies with environmental constraints as set out in the Environment Impact Assessment (EIA) and Environment Management Plan;
(ii) Engineering design, procurement and installation of electrical balance of plant: wind turbine transformers, medium voltage (MV) switch gear, underground 33 kilovolt (kV) power cables, terminations and joints, instrument transformers, protection relays and equipment, metering, supervisory control and data acquisition (SCADA) system;
(iii) Engineering design, procurement and installation of civil work balance of plant: wind turbine foundations, hardstands, road network, site office;
(iv) The delivery of large wind turbine components to Mannar Island may require a temporary pier, direct landing onto the beach, and/or road transportation. The selected contractor is required to make the necessary arrangements for design, installation and eventual removal for any such pier that is required;
(v) The contractor will be required to provide capacity building training to CEB in the subjects of working safely in wind turbines, wind farm design, wind farm equipment familiarity, wind farm SCADA and wind farm maintenance; and
(vi) A system to forecast wind park power output will be integrated with wind monitoring data and the wind park control system.

6. The wind park will be operated and maintained by the selected wind turbine contractor under a comprehensive Operations and Maintenance (O&M) agreement for a mandatory period of seven (7) years, with an option to extend by another eight (8) years. Potential bidders will be required to offer an O&M agreement that meets a set of minimum technical specifications, including a guarantee of wind turbine availability of 98% during the high wind season (May through September) and 95% during the low wind season (October through April).

1. 100 MW Wind Farm Constructed in Mannar Island of the Northern Province

7. The wind turbines will be selected through the EPC bidding process. Technical specifications include the following fundamental requirements for the offered wind turbine:

(i) In the range of 2.8 MW to 3.5 MW. This range of capacities is based on the number of wind turbine locations available and the requirement for a 100 MW total capacity;
(ii) Grid compatible type;

(iii) Horizontal rotor axis: for wind turbines of the required capacity, vertical axis wind turbines are not a viable option;
(iv) Three-bladed upwind rotor: this is the conventional design concept for commercially available wind turbines;
(v) Minimum 80 meters hub height: there are not necessarily planning restrictions on the maximum height for potential bidders, although it should be consistent with the EIA. Wind speed increases only marginally with height at Mannar;
(vi) Direct drive or geared drive system;
(vii) Power regulation with blade pitch control;
(viii) Variable speed rotor;
(ix) Active yaw drive; and
(x) Full power converter or doubly fed induction generator.

8. The selected wind turbine will conform to experience criterion set by CEB that requires the wind turbine model to be derived from a proven and successful wind turbine design platform.

2. Wind Park Infrastructure Developed

9. The wind park's internal infrastructure will include electrical and civil works parts.

10. The main electrical internal infrastructure equipment will be as follows:

(i) Switch boards and panels, measuring transformers, meters, alarm annunciators and low voltage electrical equipment contained within the wind turbine tower or nacelle;
(ii) Wind turbine transformers: can be located in an enclosure adjacent the wind turbine foundation, within the wind turbine tower or within the wind turbine nacelle;
(iii) Medium voltage switchgear: can be located in an enclosure adjacent the wind turbine foundation, within the wind turbine tower or within the wind turbine nacelle;
(iv) Wind Farm Cable Network (WFCN): this is the 33 kV cable network laid underground alongside roadways to connect each wind turbine to the Nadukuda grid substation. The WFCN will comprise six feeders originating from the grid substation and each connecting to 6–7 adjacent wind turbines in a string, with an estimated total length of 31 kilometers;
(v) Underground optical fibre network alongside roadways; and
(vi) SCADA control and monitoring system for individual wind turbines.

11. The civil works part will be provided by the EPC contractor and will comprise the following:

(i) Sub soil investigations. At least one borehole shall be drilled at each wind turbine location;
(ii) Preliminary works, temporary site installations and site mobilization;
(iii) Up to 39 wind turbine foundations, each approximately 20 meters in diameter;
(iv) Up to 39 hardstand areas or approximately 40 meters by 20 meters and adjacent assembly areas;
(v) Main service road up to approximately 15 kilometers in length, with gravel compacted surface finish including all related structures such as bridges and culverts (approximately 14 drainage crossings in total) and works;
(vi) Wind turbine approach roads, approximately 80 meters in length from main service road to each wind turbine hardstand, and minimum 4 meters width with 0.5 meter shoulders;

(vii) Other site access roads;
(viii) Selective clearing of areas, site grading of public and private roadways, lanes, vehicular paths or any other existing man made improvements which lie between the construction and right-of-way limits;
(ix) Trenching adjacent to roadways for the purposes of laying the underground power and communications cabling;
(x) Reconstruction and/or refurbishment of site roads and community roads;
(xi) Temporary pier for unloading the plant and equipment (Figure 2);
(xii) Main administrative building;
(xiii) Field offices for Employer's staff, workshops, labour camps, storing facilities, contractor's field offices, plants and equipment yards;
(xiv) For the purposes of a post-construction power curve test, one wind monitoring mast will be installed adjacent (approximately 400 meters) to wind turbine locations. The mast may be steel fabricated and consist of a concrete substructure and steel superstructure guy anchors. The mast location will be proposed by potential bidders and will be subject to confirmation by CEB.

Figure 2: Proposed pier or landing location

3. Renewable Energy Dispatch Control Center Established

12. This involves establishing a dedicated renewable energy dispatch center to forecast, control and manage intermittent 100 MW wind power generation for the proposed wind park. The control center will include a SCADA control and monitoring system for the entire wind park.

C. System Reactive Power Management Improved

13. The reactor elements of 150 MVAr will be procured and installed at locations in the electricity network to manage voltage levels within the planning limits and practical operational requirements, and ensure reliable operation of the wind park. The reactors of total 100 MVAr will be installed at the 220 kV level at the existing Anuradhapura grid substation in the North Central Province. One 50 MVAr will be installed at the 220 kV level at Mannar grid substation in the

Northern Province that is being augmented under the previous ADB loan.[1] These reactors will be in operation during the low system load period (off-peak) and will be required to be automatically (or manually) switched off based on the system load in the area or voltage level. The control functions of the reactors will be designed by CEB.

D. Capacity of Ceylon Electricity Board in project engineering design review and supervision strengthened

14. Expert consultancy services will be procured to strengthen CEB's capacity in project engineering design review and supervision. These advisory consultancy services will support CEB in ensuring engineering oversight of the wind park detailed design, wind turbine installation, commissioning and testing activities, and technical certification of contractor's activities throughout construction period.

15. The contractor will be responsible for commissioning and testing the wind farm, including:

(a) Factory acceptance tests;
(b) Site acceptance tests;
(c) Wind turbine performance tests, including:
    (i) Reliability tests of the installed wind turbines;
    (ii) A power curve test to determine whether the power curve guarantee has been achieved;
    (iii) Power system model validation and performance verifications tests; and
    (iv) A wind turbine noise emissions test to be undertaken at the discretion of CEB.

16. The consultants will also support CEB to certify these tests.

[1] ADB. 2016. *Periodic Financing Request Report: Democratic Socialist Republic of Sri Lanka: Green Power Development and Energy Efficiency Improvement Investment Program (Tranche 2) and Minor Change to the Facility.* Manila.