ATTACHMENT A - TECHNICAL SPECIFICATIONS

1.1 GENERAL REQUIREMENTS

1.1.1 A ground-mounted, single-axis tracking photovoltaic (PV) power plant is to be constructed as specified herein. The Vendor shall be responsible for:

- Size and design of the plant
- Layout of all modules and equipment
- PV technologies used
- Procurement of all equipment
- Construction and installation of all equipment
- Surveying
- Geotechnical work
- Grading and site preparation
- Site fencing
- Procuring all required permits
- Testing and commissioning
- Interfacing with Loveland SCADA for alarm notification and monitoring plant output

1.1.2 The PV system supplied is estimated to be approximately 1.6 MW; however, final sizing shall be by the Vendor and should be optimized to produce the highest annual energy output which can be constructed on the proposed site and within the estimated budget.

1.1.3 The system shall be designed in such a way that future expansion of the site is readably feasible.

1.1.4 The Vendor shall be responsible for providing a complete working system and the project shall not be considered complete until the array generates 100% of its designed output at the interconnection point based on the current environmental conditions as determined by the metering station.

1.1.5 The budget for this project is estimated as $5.1 Million

1.1.6 Work shall coordinate with the construction of the Foothills Substation which is adjacent to the PV site.

1.1.7 Schedule: The PV system must be complete and energized before December 31, 2016

1.1.8 All design and construction shall comply with the following standards

- NFPA 70: *National Electrical Code*
- IEEE C2-2012: *National Electrical Safety Code*
- *IEEE Std. 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems*
- IEEE 519-2014 - *IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems*
- ASCE 07 *Minimum Design Loads for Buildings and Other Structures*
- 2012 International Building Code including City of Loveland's Modifications
- 2012 International Energy Conservation Code
- ACI 318-14 Building Code Requirements for Structural Concrete
- All applicable OSHA requirements

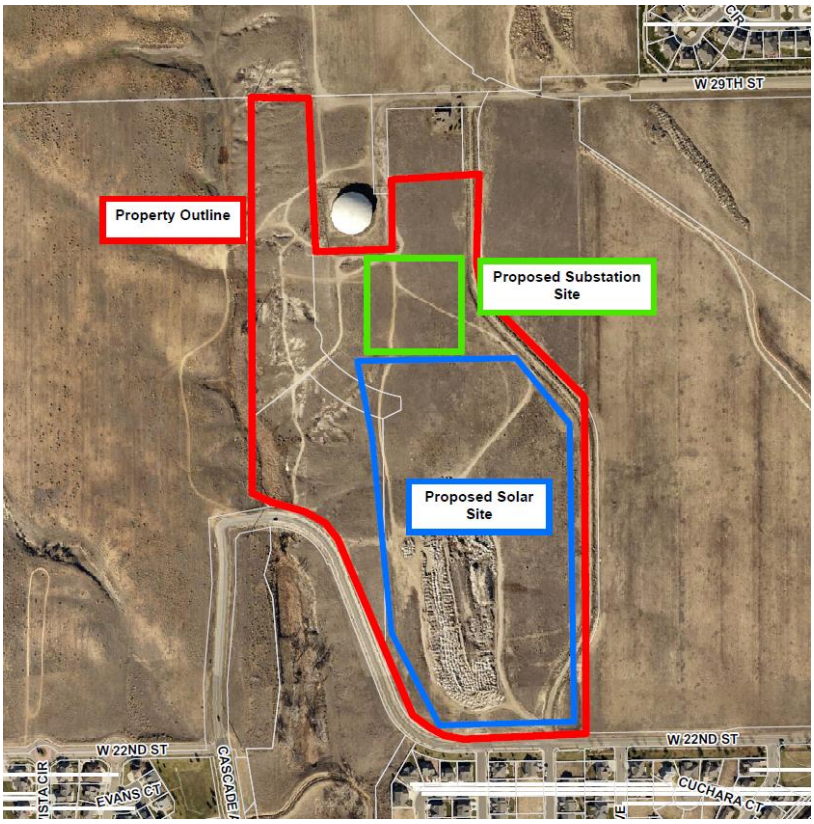
1.1.9 Grounding system shall comply with the NEC and IEEE standards for grounding in generating stations. PV system grounding system shall interconnect with the Foothills Substation grounding grid.

1.1.10 Vendor shall be responsible for all construction and construction management services including site security and safety.

1.1.11 If the Vendor provides operation services, the Vendor should include a pricing option for operation and maintenance of the facility

1.2 SITE CONDITIONS

1.2.1 Location is in Loveland, Colorado near Mehaffey Park. The site is approximately 0.5 miles west of N Wilson Ave between W 29th Street and W 22nd Street. The approximate location of the site and the proposed location of the Foothills Substation are shown in the Figure below. The amount of land available for the PV system is approximately 25 acres.



1.2.2 Elevation 5,146 ft.
1.2.3 Wind: 100 mph Exposure C
1.2.4 Ground snow load: 30psf
1.2.5 Frost depth: 30 Inches
1.2.6 Temperature range -20°F to 105°F
1.2.7 In the final design sufficient access shall be provided between array rows to permit cleaning, replacement and maintenance of the individual panels, collector boxes, junction boxes, cables, and all other equipment
1.2.8 Equipment shall be set back from the fence sufficiently to permit cleaning, replacement, and maintenance of individual panels and to meet any code or zoning requirements.
1.2.9 Sufficient access shall be provided in the final design for future replacement of transformers and inverters and maintenance of all equipment.

1.2.10 Vendor shall leave the site in a finished and clean condition upon completion of work. All trash, debris, and other material shall be removed. Vegetation control and removal shall be complete and ruts, gouges and other damage to access pathways shall be repaired and compacted to provide a serviceable site in accordance with applicable City of Loveland standards.

1.2.11 The facility shall be designed for optimal performance without sacrificing good aesthetics.

1.2.12 The engineering and design shall accommodate an expected lifetime of thirty (30) years. Photovoltaic module expected lifetime where less than 30 years shall be reported along with expected deterioration after thirty (30) years of use

1.2.13 Power system frequency is 60 Hz

2.1 UTILITY INTERCONNECTION

2.1.1 The PV system shall interconnect with the new Foothills Substation that will be constructed by Loveland Water and Power concurrently with the construction of the PV system.

2.1.2 Interconnection voltage shall be 12.47kV three-phase

2.1.3 A single 12.47kV feeder shall be supplied by Loveland Water and Power to connect the Vendor supplied PV system to the Foothills Substation. Interconnection will occur at one point, on the north side of the PV site in proximity to the proposed substation site. The Vendor shall supply, install, and commission all equipment inside the PV site up to the single point of interconnection

2.1.4 All 12.47kVcircuits shall be undergrounded, including the circuits supplying the interconnection point

2.1.5 The interconnection and all equipment, design, and procedures supplied by the Vendor shall comply with IEEE Standard 1547: *Standard for Interconnecting Distributed Resources with Electric Power Systems*

2.1.6 The PV power plant shall comply with the requirements if IEEE 519-2014 - *IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems* at the point of common coupling with the 12.47kV feeder from the Foothills Substation.

2.1.7 Vendor shall collaborate and coordinate with Loveland Water and Power on protection and relay devices and settings to adequately protect supplied equipment.

3.1 EQUIPMENT AND MATERIAL

3.1.1 All equipment shall be new and rated for the temperature and exposure conditions at the site.

3.1.2 All equipment shall be warranted by the manufacturer for a minimum of two (2) years except as otherwise noted in this specification.

3.2.1 Inverters shall comply with the following:

- 3.2.1.1 Inverters shall be grid interactive and shall be capable of disconnecting from the grid based on specific voltage conditions and be capable of low voltage ride-through. Low voltage ride-through capabilities shall be similar to those specified by FERC Order 661-A.
- 3.2.1.2 Shall be listed under UL1741
- 3.2.1.3 Shall comply with IEEE 1547
- 3.2.1.4 Inverter efficiency shall be measured and stated per IEC 61683, *Photovoltaic systems—Power conditioners—Procedures for measuring efficiency*

3.2.1.5 The inverter power factor set-point shall be controllable and remotely adjustable
3.2.1.6 Shall be lockable with enclosures rated for site conditions
3.2.1.7 Shading structures shall be provided if necessary for 100% output at the site under all environmental conditions
3.2.1.8 Shall employ a maximum power point tracking (MPPT) scheme to optimize inverter efficiency over the entire range of photovoltaic panel output
3.2.1.9 Inverters shall be equipped with all necessary hardware for data collection and communication to a SCADA central server
3.2.1.10 Shall be equipped to monitor output, condition and alarms
3.2.1.11 Surge arresters shall be installed on both the AC and DC side of the inverter
3.2.1.12 Warranty shall cover a term of at least ten (10) years
3.2.1.13 If more than one inverter is used each inverter connection shall be designed so any single inverter may be disconnected from the system for maintenance without interrupting power to any other inverter.

3.3.1 Photovoltaic modules shall comply with the following
3.3.1.1 Technology shall be by the Vendor subject to approval by the Owner. The City's preference is that Tier 1 manufacturers be used and may include:
- Mono-crystalline
- Multi-crystalline
- Thin film amorphous silicon
- Thin film cadmium telluride
- Thin film copper indium selenide
- Thin film copper indium gallium di-selenide

3.3.1.2 Shall be listed under UL1703 or certified by an OSHA-approved testing agency to meet the UL1703 standard.
3.3.1.3 Module technology:
- Manufacturer Experience.
  - The manufacturer shall have at least five (5) years of experience manufacturing photovoltaic modules.
- Manufacturing Capacity.
  - The manufacturer shall have a current minimum manufacturing capacity of at least 100 MW per year certified to the ISO9001:2008 and ISO14001:2004 standards.
  - The manufacturer shall provide the estimated annual degradation of their module.
- The maximum allowable annual degradation for modules used on this Facility shall be 2.5% in the first year and 1.0% annually thereafter.

3.3.1.4 Modules and mounting shall resist expected wind loads without damage
3.3.1.5 Modules shall be capable of resisting damage when subjected to hailstorms and the Vendor shall report the maximum diameter and velocity of the hailstone which the modules are designed to resist without damage
3.3.1.6 Linear Power Warranty shall cover a term of at least twenty-five (25) years with no less than 80% initial performance at the end of the warranty period.
3.3.1.7 All modules shall be of the same brand and model and shall be interchangeable

3.4.1 Tracking system shall comply with the following
3.4.1.1 1-axis horizontally mounted tracking system
3.4.1.2 Tracking system shall resist expected wind and seismic loading without damage

3.4.1.3 All exposed parts shall be coated, galvanized, painted, or treated to resist corrosion or be made of a material inherently corrosion resistant

3.4.1.4 The tracking system shall be of proven design and shall be of a type deployed in the field and in production for a minimum of one (1) year.

3.4.1.5 Tracking system shall cause the modules to track the sun with sufficient accuracy to achieve minimum performance standards Vendor shall specify the rotation range in the proposal.

3.4.1.6 Warranty for the tracking system and structural components shall cover a term of at least ten (10) years

3.5.1 Transformers shall comply with the following

3.5.1.1 Shall be equipped with a fused disconnect on the transformer high voltage side to isolate the transformer when necessary

3.5.1.2 Shall be rated for the expected harmonics. Transformer shall be K-rated if necessary to deliver rated output with the expected harmonic levels.

3.5.1.3 Shall have no-load tap changers allowing 2-2.5% adjustments above and below nominal voltage

3.5.1.4 Transformers shall be dead-front without exposed terminals under normal operating conditions

3.5.1.5 If more than one transformer is used the transformers shall be designed for loop feeding

3.5.1.6 Accessories shall include:

- Liquid level gauge
- Dial type thermometer with alarm contacts
- Pressure relief valve
- Drain valve with sampler

3.5.1.7 Transformers shall include lightning arresters on both the primary and secondary terminals sized to provide sufficient insulation coordination for both the high voltage and low voltage power systems.

3.6.1 Cables shall be as follows

3.6.1.1 Shall be installed underground where possible

3.6.1.2 Shall be sized for providing needed ampacity considering the site ambient temperature, soil thermal resistivity and other site conditions Cables size and type must be approved by the City before final design.

3.6.1.3 Underground cable shall be identified along its entire length with hazard tape placed 12 inches below final grade directly above the conductor.

3.6.1.4 Cable shall be installed a minimum of 36 inches below final grade

3.6.1.5 Underground splices shall be unacceptable. All splices shall be in accessible junction boxes

3.6.1.6 Where exposed above grade, cable shall be installed in PVC coated galvanized rigid conduit

3.6.1.7 Shall provide the option to have the cables installed in conduit.

3.7.1 Fencing shall comply with the following

3.7.1.1 All applicable NESC requirements

3.7.1.2 Shall be in accordance with applicable City of Loveland standards

3.7.1.3 Shall surround the entire PV site

3.7.1.3 Fencing shall be submitted to Loveland for approval

3.7.1.4 Fencing shall connect to Foothills Substation fencing

3.8.1 Combiner boxes shall comply with the following

3.8.1.1 Shall be rated for maximum system voltage and system conditions

3.8.1.2 Enclosures shall be rated NEMA 4 and shall have integral key locks or provisions for padlocking

3.8.1.3 Fuses shall have blown fuse indicators

3.9.1 Grounding system

3.9.1.1 An earthing system shall be provided for all equipment to protect personnel and equipment from lightning and other system disturbances.

3.9.1.2 Earthing resistance shall be sufficiently low to prevent damaging voltages to equipment and personnel

3.9.1.3 The earthing system shall interconnect with the earthing system for the Foothills Substation and the Vendor shall coordinate with the substation construction to provide needed material and installation for this connection.

4.1 SUBMITTALS

4.1.1 The Vendor shall submit the following with the proposal

4.1.1.1 Detailed site plan showing major equipment locations including

- Array layout
- Access roads and gates
- Switchgear (if used)
- Fencing
- Site perimeter dimensions
- Tracker motors
- Inverters
- Transformers
- Proposed interconnection point

4.1.1.2 Array size in kW

4.1.1.3 PV module manufacturer, model, and data sheet including impact rating of module

4.1.1.4 Number of PV panels

4.1.1.5 Estimated PV efficiency and output deterioration rate in percent per year.

4.1.1.6 Inverter manufacturer, model number, and data sheet including rated power, input/output voltage, and efficiency

4.1.1.7 Number of inverters

4.1.1.8 Voltage of DC collection system

4.1.1.9 One-line diagram

4.1.1.10 Estimated monthly, annual and lifetime (30 year) power plant output MWh along with assumptions used (include all site specific conditions including assumed capacity factor, soiling losses, and shading if any)

4.1.1.11 Guaranteed PV power plant annual energy output

4.1.1.12 SCADA design drawings and communication diagrams

4.1.1.13 Any deviations from or exceptions to the specifications and other bidding instructions shall be clearly listed

4.2.1 The chosen Vendor shall be responsible for all engineering for the project. All design documents, specifications, and calculations shall be sealed by a professional engineer licensed in the state of Colorado. The Vendor shall submit a 90% completed design set of drawings and data including the following to Loveland Water and Power for approval and comment prior to construction. Loveland personnel shall have ten (10) days to review the submittals and provide comments.

4.2.1.1 90% versions of all submittals from section 4.1.1

4.2.1.2 The Vendor shall design all PV array mounting systems, foundations, and piers. Foundation drawings including locations and calculations shall be submitted. If computer software is used for foundation design the program type, version, and computer file shall be submitted.

4.2.1.3 Grounding drawings and calculations

4.2.1.4 Three-line drawings

4.2.1.5 Panel schedules and loading calculations for station service

4.2.1.6 Grading and drainage plans

4.2.1.7 Road and access space dimensions

4.2.1.8 Signage drawings showing location and sign types

4.2.1.9 Conduit and cable schedule

4.2.1.10 Panel schedules

4.2.1.11 Wiring diagrams

4.1.2.12 Site lighting design

4.1.2.13 Grounding system calculations showing ground grid resistance to remote earth and estimated ground potential rise

4.1.2.14 Structural drawings of panel mounting system and tracking system

4.3.1 The chosen Vendor shall submit the following at the completion of the project:

4.3.1.1 As-built record versions of all drawings

4.3.1.2 Owner's manuals and manufacturer's data sheets for all equipment used

4.3.1.3 Copies of all manufacturer's warranties

4.3.1.4 Suggested spare parts list including as a minimum

- Number of recommended on-site spare modules
- Number of spare breakers/fuses and disconnects
- Replacement parts for trackers
- Replacement parts for inverters
- Replacement parts for transformers
- Replacement parts for collector system and cabling systems
- Other recommended spare parts

4.3.1.5 Licenses for all software, transferable to the City of Loveland

4.3.1.6 Drawing showing map of location of all underground cables

4.3.1.7 Megger or and high-pot (applicable to medium voltage cables) test reports on all cables

4.3.1.8 Factory test reports on inverters

4.3.1.9 Factory test reports on transformers

4.3.1.10 Foundation test reports, pile tests, concrete tests, etc.

4.3.1.11 PV open circuit measurement reports

4.3.1.12 Grounding system tests

4.3.1.13 Metering and relay calibration test reports

4.3.1.14 Transformer test reports

4.3.1.15 Documentation of PV module factory testing

4.3.1.16 Operating and maintenance instruction manuals

4.3.2 All final drawings, calculations, computer programs, and other material used in the design and construction of the plant shall become the property of the City of Loveland and shall be delivered to Loveland in Autocad formant for all drawings and Microsoft Word for all other printed documents. Manufacturer's cut sheets may be in Adobe PDF formant, and calculations done by computer program may be delivered in the native format of the program used.

5.1 MONITORING AND SCADA

5.1.1 The facility shall be supplied with at least one permanently installed meter specified as follows:
- 5.1.1.1 Accuracy class of 0.06% or better at the connected burden
- 5.1.1.2 Capable of measuring and displaying harmonics up to and including the 50th
- 5.1.1.3 Meter shall measure and record energy production
- 5.1.1.4 Manufacturer shall provide all necessary programming software
- 5.1.1.5 Meter shall be programmable using an EIA-232 connection
- 5.1.1.6 Meter shall include a 100BASE-FX Fast Ethernet Fiber-Optic Port
- 5.1.1.7 Meter shall accommodate 100 Base-T Ethernet connection
- 5.1.1.8 Meter shall accommodate Modbus and DNP3 protocols over Ethernet
- 5.1.1.9 Metering current transformers shall be a minimum accuracy class of 0.3% at installed burden
- 5.1.1.10 Metering voltage transformers shall be a minimum accuracy class of 0.3% at installed burden

5.1.2 The facility will be supplied with sufficient metering in the inverters to permit measurement and calculation of plant losses

5.1.3 The Vendor shall provide a minimum of one meteorological station to provide data to facilitate the evaluation of facility performance. The meteorological station pyranometer shall meet the ISO-9060 specification for measurement of solar irradiance. Station shall be capable of recording data and communicating data to a central SCADA location and shall retain all recordings for a minimum of 24 hours after loss of AC power.

5.1.4 Vendor shall supply an engineering work station providing local monitoring and control of inverters and plant output and shall comply with the following:
- 5.1.4.1 Shall include a human-machine interface (HMI)
- 5.1.4.2 Shall include input/output (I/O) to monitor and control all inverters
- 5.1.4.3 Shall communicate with inverters via fiber-optic channels
- 5.1.4.4 Shall be located in the control room of the adjacent Foothills Substation
- 5.1.4.5 Shall provide for and include
  - Real time plant output monitoring to include as a minimum:
    - AC voltage
    - DC voltage
    - AC current
    - DC current
    - kW
    - kWh
    - Transformer disconnect switch position
    - Inverter DC voltage
    - Inverter DC current
    - Current date and time
    - PV system temperature
    - Solar irradiation
  - Remote alarm monitoring including as a minimum:
    - Inverter alarms
    - Transformer alarms
    - Electronic fault log
  - Alarm management
  - Control including at least the following:
    - Ability to control inverter power factor

    - Ability to control inverter real power output
    - Ability to cause the array tracking system to immediately store the array in a “safe” condition when necessary at the command of an operator
    - Ability to cause the array tracking system to automatically store the array in a “safe” condition when inclement or damaging weather conditions are indicated
    - Ability to cause the array to cease all output
  - Historical trending of all measured values
  - Fiber optic communication
  - Ethernet communication
  - Include all needed control and monitoring software
  - Real time and historical trending of meteorological data to include at least:
    - Ambient air temperature
    - Reference irradiation
    - Wind speed
    - Wind direction
  - Internet-based monitoring and data downloading
  - Event logging

5.1.4.6 SCADA system shall monitor and store data from the plant output meter on an interval of 10 seconds

5.1.4.7 SCADA system calculates and displays the following as a minimum

- Day’s net energy generation in kWh
- Month’s net energy generation in kWh
- Year to date net energy generation in kWh
- Total lifetime net energy generation in kWh

6.1 COMMISSIONING AND STARTUP

6.1.1 The vendor shall provide commissioning and startup services which will include the following. A written report including the measured values observed during commissioning shall be provided to Loveland. Loveland may, if desired, witness all testing procedures.

6.1.1.1 Verification that inverters operate correctly and SCADA control and monitoring is fully and correctly functioning

6.1.1.2 Verification that the tracking system operates as designed and all controls operate correctly

6.1.1.3 Test all system alarms for correct function and display

6.1.1.4 Test communication systems for correct function

6.1.1.5 Test all meters, breakers, and relays

6.1.1.6 Test continuity and resistance of the grounding system

6.1.1.7 Test plant output and submit test documentation proving the plant meets all performance guarantees

6.1.1.8 Work with Loveland personnel to integrate the PV system SCADA system with Loveland’s SCADA system

6.1.2 The Vendor shall provide training for Loveland personnel for startup, shutdown, maintenance, and operation of the PV power plant.