Exhibit D.5.2
PV Module Technical Requirements and Guidelines

Doc ID	MRG
Revision	2023_1
Release Date	16th November 2023

Contents

1. **Introduction** **3**

2. **Purpose** **3**

3. **Product Requirements** **4**

3. 1. Performance and Physical Specifications 4

3. 2. Material Specifications 6

3. 3. Certification Requirements 6

3. 4. Warranty Requirements 7

3. 5. Preventing Forced Labor 7

4. **Manufacturing Requirements** **8**

4. 1. Build Requirements 8

4. 2. Factory Requirements 8

4. 3. Process Requirements 8

5. **Technical Diligence Requirements** **9**

5. 1. Extended Durability Testing 9

5. 2. Pre-Production Factory Audit 9

6. **Quality Assurance Requirements** **10**

6. 1. Production Supervision 10

6. 2. Pre-Shipment Inspection 10

6. 3. Pre-Shipment Testing 11

6. 4. Container Loading and Packaging Inspection 11

6. 5. Post-Shipment Inspection 12

1. Introduction

Xcel Energy ("Company") has set minimum requirements for the technical specifications, third-party diligence, and quality assurance for PV modules ("modules") used in Company acquired projects. These requirements are designed to help assure the long-term safety, reliability, and performance of the acquired assets.

These requirements are split into the following sections:

- **Products and manufacturing** – minimum standards for modules and their manufacturing.
- **Technical diligence** – module testing and manufacturing audits required in advance of production.
- **Quality assurance** – module inspection, testing and manufacturing oversight required during and after production.

These requirements apply to **crystalline silicon-based modules** with the following variations:

- PERC, TOPCon and HJT technology-based modules.
- Mono- and bi-facial modules.
- Full size and cut-cell modules.

Thin film-based modules (First Solar only) are not considered. If First Solar thin-film modules are proposed, please consult with your representative at Company for the appropriate requirements and guidelines.

Why is quality important?

These requirements and guidelines apply the basic principle that long-term module reliability and performance is determined by the quality of materials used in a module and the quality of the manufacturing process used to assemble them.

2. Purpose

The purpose of this document is for Company to set clear minimum requirements for the technical specifications, diligence, and quality assurance of modules, but also to provide project developers with sufficient information to plan for and satisfy these requirements.

This document is not intended to provide the details, direction or guidance for specific module types or manufacturers. As a project progresses the specifics should be defined together with Company, the selected manufacturer(s) and independent engineers or advisers hired to work on behalf of Company.

These requirements will impact your supply agreement(s) for modules!

It should be noted that to meet the requirements and guidelines described in this document, appropriate terms and language must be included in your module supply agreement for the project. It is therefore important that a supply agreement is not concluded before negotiating the terms necessary to meet these requirements. Company can assist in this process.

3. Product Requirements

3. 1. Performance and Physical Specifications

- The manufacturer must produce and deliver modules that are compliant with the manufacturers' technical datasheet. The datasheet should form the contractually binding technical specification for the module. Any reference on the datasheet to specifications being subject to unilateral change by the manufacturer should be removed prior to the datasheet being incorporated into a supply agreement.
- The technical datasheet must include all specifications that impact the factory-gate performance of the module under real field conditions including at minimum:
    - Nominal output power, efficiency, current and voltage under standard test conditions.
    - Nominal output power tolerance (positive only).
    - Output power under varying irradiance and operating temperatures.
    - Temperature coefficients.
    - Bifacial coefficient for bifacial modules together with any applicable (+/-) tolerance.
    - Maximum system voltage
- The technical datasheet should also specify the major physical attributes of the module:
    - Size and weight.
    - Cable lengths, connector type and specification (including connector compatibility).
    - Maximum certified and warranted wind and snow loads.
    - Maximum certified and warranted hail resistance (by maximum hail size).
- It must be ensured that the design loads (wind, snow, and hail) for any project are not expected to exceed the certified and warranted loads of the module (after applying a minimum 1.75x safety factor and considering the exact module mounting configuration to be used). Results of physical load tests conducted out on the exact same module type and construction should be obtained to verify that these requirements can be met without any module damage or power loss. The total physical deflection of the module while under test may not exceed 1 inch (25mm). A mounting compatibility letter should also be obtained from the manufacturer confirming that the modules are certified and warranted when installed and operated according to the above.
- A third party validated .PAN file must be provided for the module type(s) being sourced. This file must have been generated based on testing modules with the same or similar bill of materials ("BOM") that will be used in the project (at minimum the type of cell and glass used in the test modules must be the same as those in the modules delivered to the project).

- A third-party PAN file test report must be obtained from the manufacturer. The testing should have been conducted by a reputable, independent testing agency. The third-party reported PAN file values should match those in the PAN file provided by the manufacturer.
- Modules shall be IEC or UL 61215 certified up to a hail size of **25mm** [for Module use in low hail risk regions], **45mm** [for Module use in medium hail risk regions] and/or **55mm** [for Module use in high hail risk regions].
- Ultra-large format Modules are not approved by the Company. The Company considers Modules to be ultra-large format if they are wider than 1.2m or heavier than 34kg.

3. 2. Material Specifications

- The materials used to assemble the modules (BOM) must be declared in advance by the manufacturer and be described in all unique combinations the manufacturer intends to use them (especially if multiple material combinations may be used for the same module type).
- The modules should be manufactured using only the declared BOM combinations. The declared BOM combinations should include the front superstrate, rear substrate, encapsulant, solar cells, solar cell interconnect ribbons, soldering flux, junction box, junction box pottant, bypass diode, cables and connectors, frame, and frame sealant. Each material should include the supplier's name, the material type, a unique part or material identifier and the physical origin of the material.
- Evidence to validate that the module type and the declared BOM combination meet the certification requirements described in Section 3.3 must be provided. This is validated by accessing copies of the Certificates as well as the Constructional Data Forms (CDFs) produced by the certifying agencies.
- It is recommended that the manufacturer provide a Material Safety Data Sheet (MSDS) for the modules as well as toxicity test reports per the Federal TCLP and/or California Title 22 TTLS/STLC.
- The valid installation, operating and maintenance manual for the modules must be incorporated and referenced in the supply contract. The manual should be reviewed to ensure that no inadvertent loss of warranty coverage will occur due to the manner of install, operation, and maintenance (O&M) deployed in the field.
- Each module should be permanently labeled with a unique ID number to ensure traceability and identification of the module throughout its' operational life.

3. 3. Certification Requirements

The following certification requirements apply:

Standard	Title	Application
Modules		
UL 61215:Ed.2-2021	PV Module Design Qualification and Type Approval	North America
UL 61730:Ed.2-2022	PV Module Safety Qualification	North America
IEC 61701:2020	Salt Mist Corrosion Testing	Marine/coastal applications only *
IEC 60068-2-68	Environmental Testing – Dust and Sand	Desert applications only
IEC 62716:2013	Ammonia corrosion testing	Agricultural applications only
IEC 62979:2017	Bypass Diode Thermal Runaway Test (I & V based @90°C)	High temperature, hard-shaded applications only
IEC 63126:2020 MQT 18	Bypass Diode Thermal Test (1.4 x I_{sc}, temp. levels 1 and 2)	High temperature, hard-shaded applications only

Module Packaging		
IEC 62759:2022	Transportation Testing (for the module packaging)	Global
Factories		
ISO 9001:2015	Quality Management System	Global
ISO 14001:2015	Environmental Management System	Global
ISO 45001:2018	Occupational Health & Safety Management System	Global

* Junction box and connectors must be marine grade

3. 4. Warranty Requirements

- The modules should be provided with a product workmanship warranty with a term of at least 10 years and a power warranty that has a term of at least 25 years with a maximum allowable power loss of 0.5% per year (after year 1).
- Warranties should include a typical serial defect clause requiring all modules to be repaired or replaced within or beyond the warranty period if more than a reasonable percentage (maximum 10%) of modules across a project are known to be defective.
- For bifacial modules, it is recommended that the power warranty covers power degradation for both the front and rear side of the modules.

3. 5. Preventing Forced Labor

- The manufacturer should have a code of conduct (or similar policy) that commits the manufacturer to avoid the use of forced labor conditions at their manufacturing facilities as well as their equipment, material, and component suppliers, including but not limited to the silicon supply chain including wafers, ingots, and polysilicon.
- The manufacturer should have a robust supply chain documentation program providing traceability of materials including but not limited to the silicon supply chain including wafers, ingots, and polysilicon, and that such documentation is freely available to review and includes relevant information including manufacturer name, location/date of production, and unique and traceable lot identification.

4. Manufacturing Requirements

4. 1. Build Requirements

The following requirements apply to the general condition of modules supplied:

- Modules should be new build only and subject to the quality assurance requirements described in this standard; modules from stock or inventory that cannot be subject to these standards should not be accepted.
- Modules that have been repaired or re-worked should not be accepted unless such repair or rework takes place prior to module lamination. Rework specifically prohibited includes removal or replacement of cells, encapsulants, back-sheets, glass, frames, or junction box after initial assembly.

4. 2. Factory Requirements

The following requirements apply to the locations used to manufacture the modules being supplied:

- The specific factories and workshops to be used to manufacture the modules should be declared in advance by the manufacturer. The same factories and workshops must be subject to the technical diligence and quality assurance requirements of this document.
- Any change to the factories and workshops to be used – either in advance of or during production - may only take place if the new factory and/or workshops meet the technical diligence and quality assurance requirements of this document.

4. 3. Process Requirements

The following basic requirements apply to the process used to manufacture the modules being supplied:

- All finished modules must be subject to electro-luminescence (EL) imaging as part of outgoing quality control (OQC) at the factory. Company may require the EL images for all modules be stored in a database of quality related data for the project (each image identified by module serial number).
- EL imaging should be undertaken with sufficient resolution to reliably identify and display any latent cell defects that may impact module performance and reliability. Digital files must be retained with sufficient image resolution. Images must be clearly focused and sufficiently contrasted.
- All finished modules must be subject to flash testing using an AAA-grade flash tester which is regularly calibrated, including use of modules which have been calibrated within the past twelve (12) months by an internationally recognized calibration laboratory.
- Flash testing should be conducted at standard test conditions (STC) according to IEC 61215-2:2016 MQT 6.1 and for bifacial modules according to IEC 60904-1 and -2 (Measurement of Current-Voltage Characterization of Bifacial Photovoltaic Devices). The flash test data recorded for each Module should be made available. Company may require that the flash data for all modules be stored in a database of quality related data for the project.
- The flash test data shall include the module serial number and associated STC power (W), open circuit voltage (V), short circuit current (A), maximum power voltage (V), maximum power current (A). The

flash test data for the front-side of all modules should be provided by the manufacturer. Rear-side flash test data for bifacial modules must be provided in addition and include a statistically significant sample of rear-side flash test data that is representative of the modules shipped to the project. The measurement accuracy of each flash tested parameter should also be stated.

⚠ **Any modules which do not meet the electrical or mechanical specifications according to the technical datasheet should be rejected.**

5. Technical Diligence Requirements

5. 1. Extended Durability Testing

- The module type with the declared BOM combination(s) should have been (or be) subject to Extended Durability Testing at an independent ISO 17025 accredited test lab specialized in testing PV modules. The testing protocol must be CSA/ANSI C450 compliant.
- Modules may be tested by labs such as PVEL through the latest revision of their Product Qualification Program (PQP) or an equivalent extended duration testing program at another recognized third-party test lab. The manufacturing of the modules used for testing should be witnessed by an independent third party to verify the materials used match the declared BOM combination(s).
- Test results may be available off-the-shelf in which case new testing is not required. Repeat testing is also not required if the same module type and declared BOM combination(s) are used in multiple projects.
- Power degradation after any individual extended durability test sequence shall not exceed 5% (applied to both front and back of the modules for bifacial modules) and there should be no drop in the bifacial coefficient (for bifacial modules). Power degradation after LID testing should not exceed 1% and power degradation after LeTID testing should not exceed 2%.

5. 2. Pre-Production Factory Audit

A pre-production audit of the factories and individual workshop(s) to be used to produce modules should be conducted. The following requirements apply to the pre-production audit:

- The audit should assess the manufacturers' compliance to their own manufacturing standards and assess any potential risk to the safety, reliability, and performance of the modules.
- An independent Factory Auditor specialized in conducting such compliance and risk assessment audits should be used. The Auditor must be sponsored by the buyer and not by the manufacturer.
- The module type to be purchased, or equivalent, should be in production at the time of the audit to ensure relevance of the results.
- The audit shall assess the following areas within module production:
    - Factory management including supply chain, production and quality
    - Conformance to module certification
    - Incoming inspection, storage, use and control of materials (IQC)
    - All module assembly processes, related process controls (IPQC) and documentation

- All module inspection and testing processes, controls, and documentation (OQC)
- Equipment maintenance and calibration; finished goods management

⚠ **The manufacturer is expected to correct any audit non-compliances or mitigate any identified risks before production start for the project, adopt such improvements in the standard operating procedure for the project and maintain them during production for the project.**

6. Quality Assurance Requirements

6. 1. Production Supervision

The production of modules should be overseen in-factory by independent Factory Inspectors hired to work on behalf of the buyer. The goal of production supervision is to ensure that the manufacturer maintains compliance to their standard operating procedures and any improvements made as a result of the pre-production factory audit. It must take place during production of modules for buyer. The basic production supervision requirements are as follows:

- Production supervision should oversee incoming quality controls, conformance to the declared BOM combination(s), equipment maintenance and calibration, all major material, process, production and environmental controls and all the major outgoing quality controls such as flash testing, EL imaging, visual inspection, and safety testing.
- The Factory Inspector must have the right to enter the factory at any time during production of modules for the buyer. Production supervision should be conducted at a frequency no less than one randomly selected instance per week covering approximately **20%** of the total volume of product.

⚠ **Any significant deviations in processes or procedures, which may negatively impact the safety, reliability, and performance of the modules, must be identified, and promptly reported. The manufacturer should then quarantine any potentially non-compliant modules for further inspection. Any defective modules must be replaced before shipment.**

6. 2. Pre-Shipment Inspection

Modules should be sampled from finished goods at the factory and subject to repeat inspection by the Factory Inspector. The goal of pre-shipment inspection is to identify overt or latent defects in the finished modules before shipment. The pre-shipment inspection requirements are as follows:

- Production should be split into reasonably sized batches in the range of **5 to 10 MW** (depending on the size of the project) to ensure inspections are conducted at least weekly during production.
- Modules for re-inspection should be sampled according to ISO 2859 rules by applying the following:
  - General Inspection Level **II**
  - AQL for critical defects of **0** (defects impacting safety)
  - AQL for major defects of **0.65** (defects impacting performance and reliability)
  - AQL for minor defects of **4.0** (defects not impacting safety, performance, or reliability)
- The AQLs should be applied in aggregate to all methods of inspection.

- The sampled modules should be subject to repeat visual inspection, EL-imaging, and flash testing under the direct supervision of the Factory Inspector. The inspection criteria to be applied should be defined upfront in the supply contract. The front- and rear-side of bifacial modules should be repeat flash tested for all modules subject to pre-shipment inspection.
- All modules from the batch being inspected should be held at the factory and not be released for shipment until the pre-shipment inspection has been completed and shown to meet the AQL standards defined above.

⚠ **Any defects which are identified that negatively impact the safety, reliability, and performance of the modules, must be promptly reported. The manufacturer should replace any modules identified with critical or major defects before shipment of the batch.**

6. 3. Pre-Shipment Testing

Modules should also be sampled from production for pre-shipment testing at the manufacturers' in-house lab. They should be sampled from the same batches of modules subject to pre-shipment inspection. The *minimum* testing requirements are as follows:

- The modules should undergo the following tests:
  - Wet leakage testing
  - Gel content testing
  - Peel strength testing
  - Light Induced Degradation (LID)
  - Potential Induced Degradation (PID)
- A minimum of two (2) modules should be subject to each test. Each test should be conducted on samples extracted from each batch produced. The tests should be repeated for each BOM combination used in a batch of modules.
- Power degradation after the LID and PID tests shall not exceed 1 and 5% respectively (applied to both front and back of the modules for bifacial modules) and there should be no drop in the bifacial coefficient (for bifacial modules). The manufacturers standard acceptance criteria should be applied to the wet leakage, gel content and peel strength tests.

⚠ **Power loss that exceeds 5%, or other obvious defects, should immediately be reported. The manufacturer should identify root-cause, the population of modules affected by the defect(s) and provide suitable remedy.**

6. 4. Container Loading and Packaging Inspection

Container loading and packaging inspection should be conducted to make sure that packaged modules are in good, acceptable condition ready for international shipment from the factory.

6. 5. Post-Shipment Inspection

Modules should be sampled from containers delivered to the buyer and subject to repeat inspection by a Field Inspector. The goal of post-shipment inspection is to identify overt or latent defects in the finished modules after shipment, especially those that may have been caused or become apparent during shipping. The post-shipment inspection requirements are as follows:

- Modules for post-shipment inspection should be sampled from individual containers according to ISO 2859 rules by applying the following:
    - General Inspection Level **S4**
    - AQL for critical defects of **0** (defects impacting safety)
    - AQL for major defects of **1.5** (defects impacting performance and reliability)
    - AQL for minor defects of **4.0** (defects not impacting safety, performance, or reliability)
- The AQLs should be applied in aggregate to all methods of inspection.
- The sampled modules should be subject to repeat visual inspection and EL-imaging. The same inspection criteria applied at the factory should be used.
- The buyer may elect not to inspect modules from every container, but a **minimum of 20%** of all containers should be inspected.