RENEWABLE ENERGY FUND
POWERED BY RHODE ISLAND COMMERCE

Minimum Technical Requirements for the Renewable Energy Fund (REF)

All Rhode Island Renewable Energy Fund projects must demonstrate compliance with the Minimum Technical Requirements set forth in this document. These requirements are not intended to be all-encompassing, nor are they intended to be a substitute for engineering specifications, relevant codes and standards, or for safety requirements. Site-specific conditions and/or local regulations may stipulate additional requirements not contained in this attachment. Commerce RI reserves the right to withhold payment to any project that does not satisfy the Minimum Technical Requirements.

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Solar Photovoltaic (PV)

Required Inspection and Inspection Process

All installations are subject to a third-party inspection. Installers must submit self-inspection reports along with the rest of the completion documents for all installations. Projects paired with energy storage must submit the PV + ESS-specific self-inspection report. Third-party reviews will begin as self-inspections and may be shifted to virtual or on-site at the discretion of the inspector, based on the clarity and comprehensiveness of the self-inspection report provided. The inspector will coordinate the site visit with the installer via email if an inspection is shifted to virtual or on-site. For all on-site inspections, **the installer is responsible for providing safe access to all system components** including the array, wiring within enclosures, and all other areas associated with the PV system.

A Self-Inspection Review Memo or Inspection Report, and if required, a Correction Action Report (CAR), will be issued after each inspection. Projects that score a 4 or 5 will be approved for grant payment, however, any identified issues must be corrected. Projects that score a 3 or lower must have all corrections approved before grant payment is released.

Shading and Estimated Production Requirements

The PV project must be designed so that the estimated annual energy output is at least 80% of the default optimal output for a fixed PV project of the same capacity, as estimated by PVWATTS or a similar tool. Optimal parameters for purposes of a PVWATTS estimate are:

1) 0.89 DC to AC derate factor,
2) 42° array tilt, and
3) 180° (True South) azimuth. PVWATTS is available at the followingwebsite: http://pvwatts.nrel.gov.

The PV project must have a measured total solar resource fraction (TSRF) of 0.8 or greater and is subject to TSRF verification by Solmetric SunEye (or equivalent shade measurement tool) during onsite inspection. TSRF is a measure of the actual expected irradiance divided by the total irradiance available to a system with optimal siting characteristics (tilt, azimuth, etc.). Note that shading losses are incorporated into the TSRF and that a low TSRF can be the result of shading, non-ideal orientation, or both.

The following shade measurement tools/applications are approved by Commerce RI:

Name	Type	Condition
Aurora	Application	Must use LIDAR data.
Bright Harvest	Application	
HelioScope	Application	Must use LIDAR data.
Scanifly	Application	
Solar Pathfinder	Tool	Four-corner measurement for each array.
Solargraf	Application	Must use LIDAR data.
Solmetric SunEye	Tool	Four-corner measurement for each array.

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All other methods for reporting TSRF must be proposed to, and approved by, Commerce RI prior to submitting an incentive application. All shading reports edited to indicate the future removal of obstructions must submit proof of such removal. Shade measurements must accurately reflect as-built conditions and array layouts.

Shade Measurement Applications

Shade measurements using applications must model all obstructions within a 100-ft radius and will be subject to an onsite Solmetric SunEye or Solar Pathfinder TSRF verification. Onsite measurement and verification takes precedence over the desktop tools' estimates.

Shade Measurement Tools

When measuring TSRF, applicants must take measurements at all four corners of each proposed array location. An array is defined as a complete grouping of modules with the same azimuth and tilt and does not experience any direct obstruction. For example, an obstruction could be considered a dormer between modules on a roof with the same tilt and azimuth, or a rooftop HVAC system between modules on a roof with the same tilt and azimuth. The TSRF for each array is the mean of the readings taken at each of the four corners of the array. The overall TSRF is a weighted average of the individual array TSRF values, weighted by nameplate capacity. For example, a system with two arrays:

- Array 1: TSRF = 90%, Capacity = 5 kW
- Array 2: TSRF = 70%, Capacity = 6 kW

This system would have an overall TSRF of (0.9)(5kW)+(0.7)(6kW) divided by 11kW, or 0.79, and would therefore be ineligible for an incentive.

Roof Requirements

- PV arrays shall not be installed on any roof that is expected to be replaced within 10 years, or that contains damage that may require repair or early replacement.
- Solar PV projects designed to be installed on pitched, non-flat roofs, are required to have an azimuth that is the same as the roof azimuth.

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Installation Requirements

All installations must follow the most **current adopted edition of the National Electrical Code (NEC)** with the following amendments, as noted below. In all cases where third-party guides/handbooks, or other materials contradict the most current edition of any local, state, or federal code, the applicable code shall take precedence over such materials.

- Twist-on wire connectors (wire nuts) shall not be used in any outdoor enclosure unless listed to UL 486D for use in damp/wet locations. Proof of listing will be required during inspection if applicable. (See NEC 110.28 for more information.)
- Residential installations of ground- and pole-mounted arrays must contain a disconnect switch as described in NEC 690.15, located at the array to isolate all DC current carrying conductors leaving the array. This is not required where the ground- or pole-mounted array consists entirely of AC modules, DC-DC converters (optimizers), or microinverters.
- Areas where wiring passes through ceilings, walls, or other areas of the building must be properly restored, booted, and sealed. Thermal insulation in areas where wiring is installed must be returned to "as found or better" condition.

Commerce RI requires that photos be taken of all system components, including:

- **Array and PV modules:**
  - Array overview, module nameplate, wire management, and grounding
- **DC connectors:**
  - Module, module-level power electronics, and field-installed
- **Module-level power electronics:**
  (including microinverters, DC optimizer, and rapid shutdown devices)
  - Nameplate, mounting, grounding
- **Junction boxes/electrical enclosures:**
  - Exterior, interior wiring, grounding
- **DC disconnect and/or DC combiner:**
  - Exterior, interior wiring, overcurrent protection, nameplate
- **Inverter(s):**
  - Exterior, interior wiring, overcurrent protection, nameplate
- **AC disconnect/AC combiner:**
  - Exterior, interior wiring, overcurrent protection, nameplate
- **Interconnection:**
  - Grid connection method, overcurrent protection, nameplate, wiring, grounding

These photos shall be kept on record with the primary installer and made available to Commerce RI upon request.

An owner's manual of operating and maintenance instructions must be provided to the PV project owner and preferably also posted on or near the PV project. The owner's manual should include manufacturer's specifications, serial numbers, warranty policies, etc.

Owners must be provided with, at minimum, a basic training orientation that includes maintenance instructions, troubleshooting, meter reading, and electric production reporting instructions.

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Energy Storage

Technology Requirement

Energy storage technologies that satisfy all technical eligibility criteria of RI Energy's Connected Solutions[1] program are eligible for this program.

[1] https://www.rienergy.com/site/ways-to-save/save-money-with-rebates-and-incentives/connectedsolutions/battery-program

Installation Requirements

All installations must follow the most **current adopted edition of the National Electrical Code (NEC)** with the following amendments, as noted below. In all cases where third-party guides/handbooks, or other materials contradict the most current edition of any local, state, or federal code, the applicable code shall take precedence over such materials.

- Twist-on wire connectors (wire nuts) shall not be used in any outdoor enclosure unless listed to UL 486D for use in damp/wet locations. Proof of listing will be required during inspection if applicable. (See NEC 110.28 for more information.)
- Areas where wiring passes through ceilings, walls, or other areas of the building must be properly restored, booted, and sealed. Thermal insulation in areas where wiring is installed must be returned to "as found or better" condition.

Commerce RI requires that photos be taken of all system components, including:

- **Battery modules:**
  - Installation overview, nameplate, interior wiring, grounding
- **Junction boxes/electrical enclosures:**
  - Exterior, interior wiring, grounding
- **DC disconnect and/or DC combiner:**
  - Exterior, interior wiring, overcurrent protection, nameplate
- **Inverter(s):**
  - Exterior, interior wiring, overcurrent protection, nameplate
- **AC disconnect/AC combiner/ESS disconnect:**
  - Exterior, interior wiring, overcurrent protection, nameplate
- **Microgrid interconnect device (MID)/isolation switch:**
  - Exterior, interior wiring, overcurrent protection, nameplate
- **Interconnection:**
  - Grid connection method, overcurrent protection, nameplate, wiring, grounding

These photos shall be kept on record with the primary installer and made available to Commerce RI upon request.

An owner's manual of operating and maintenance instructions must be provided to the ESS project owner and preferably also posted on or near the ESS project. The owner's manual should include manufacturer's specifications, serial numbers, warranty policies, etc.
Owners must be provided with, at minimum, a basic training orientation that includes maintenance instructions, troubleshooting, meter reading, and electric production reporting instructions.

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Solar Hot Water

System Warranties and Certifications:

SHW systems must be whole systems (tanks, collectors, controls, and plumbing). Components must be new, and collectors must be certified to the OG-100 or OG-300 standard by an accredited testing laboratory, such as the Solar Rating and Certification Corporation ("SRCC") or the International Association of Plumbing and Mechanical Officials ("IAPMO"). SHW systems must be backed by a minimum 10-year manufacturer's warranty for collectors, two (2)-year warranty for other system components, and a two (2)-year comprehensive installation warranty.

Required Inspection and Inspection Process

Installed systems must meet all applicable state and local laws and ordinances. The Installer must attest that the Project has received a building and/or plumbing permit and has completed a satisfactory plumbing inspection by the local authority. All installations are subject to a third-party inspection. Prior to the inspection taking place, the installer will be notified via email of the inspection. The installers should make all reasonable attempts to attend the inspection. An inspection report will be issued after each inspection. All corrections must be approved before grant payment is released.

Shading and Estimated TSRF Requirements

Solar Hot Water projects must have a total solar resource fraction (TSRF) of 0.8 or greater and is subject to TSRF verification by Solmetric SunEye (or equivalent shade measurement tool) during onsite inspection. TSRF is a measure of the actual expected irradiance divided by the total irradiance available to a system with optimal siting characteristics (tilt, azimuth, etc.). Note that shading losses are incorporated into the TSRF and that a low TSRF can be the result of shading, non-ideal orientation, or both.

The following shade measurement tools/applications are approved by Commerce RI:

Name	Type	Condition
Aurora	Application	Must use LIDAR data.
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Scanifly	Application	
Solar Pathfinder	Tool	Four-corner measurement for each array.
Solargraf	Application	Must use LIDAR data.
Solmetric SunEye	Tool	Four-corner measurement for each array.

All other methods for reporting TSRF must be proposed to, and approved by, Commerce RI prior to submitting an incentive application. All shading reports edited to indicate the future removal of obstructions must submit proof of such removal. Shade measurements must accurately reflect as-built conditions and array layouts.

Minimum Technical Requirements for the Renewable Energy Fund

Shade Measurement Applications

Shade measurements using applications must model all obstructions within a 100-ft radius and will be subject to an onsite Solmetric SunEye or Solar Pathfinder TSRF verification. Onsite measurement and verification takes precedence over the desktop tools' estimates.

Shade Measurement Tools

When measuring TSRF, applicants must take measurements at all four corners of each proposed array location. An array is defined as a complete grouping of collectors with the same azimuth and tilt and does not experience any direct obstruction. For example, an obstruction could be considered a dormer between collectors on a roof with the same tilt and azimuth, or a rooftop HVAC system between collectors on a roof with the same tilt and azimuth. The TSRF for each array is the mean of the readings taken at each of the four corners of the array. The overall TSRF is a weighted average of the individual array TSRF values, weighted by nameplate capacity. For example, a system with two arrays:

- Array 1: TSRF = 90%, Capacity = 5 kW
- Array 2: TSRF = 70%, Capacity = 6 kW

This system would have an overall TSRF of (0.9)(5kW)+(0.7)(6kW) divided by 11kW, or 0.79, and would therefore be ineligible for an incentive.

Roof Requirements

Solar Hot Water arrays shall not be installed on any roof that is expected to be replaced within 10 years, or that contains damage that may require repair or early replacement.

System Minimum Technical Requirements

Systems must include the installation of solar thermal collectors that transfer the absorbed solar radiation to a fluid passing through the collectors.

Collector Area and Mounting:

- Collectors must SRCC OG-100 certified
- Collector tilt must follow manufacturer specifications.
- Orientation must be between ninety (90) degrees and two hundred seventy (270) degrees true.
- Collectors must be secured according to manufacturer's recommendations.

Storage:

- All systems must follow the manufacturer's recommendations regarding storage capacity;
- The storage tank should be at least as large (in gallons) as the Project Site's estimated daily use (in gallons per day); and
- The storage tank's volume (in gallons) should hold approximately one and a half (1.5) gallons per square foot of collector area.

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Plumbing:

- All systems shall include one of the stagnation methods:
  - Advanced controller with vacation or holiday mode;
  - Advanced controller with thermal cycling function;
  - Heat dump radiator;
  - Steam back;
  - Pressure stagnation protection; or
  - Other (requiring approval by REF)
- All systems shall include one of the freeze protection methods
  - Direct forced circulation (open loop): Automatic freeze drain valve;
  - Indirect forced circulation (closed loop): Active closed-loop glycol;
  - Indirect forced circulation (closed loop): Closed-loop glycol or water drainback;
  - Thermosiphon: Closed-loop glycol;
  - Glycol drainback; or
  - Other (requiring approval by REF)
- The Primary Installer shall provide assurances for freeze protection to at least negative twenty-seven (-27) degrees Fahrenheit in the case of pressurized systems, or nine (9) degrees Fahrenheit for drainback systems.

Insulation:

- All systems must have insulation on all exposed and accessible hot water piping. Underground circulation lines must be below the frost line.

System Labeling:

- Drain and Fill Valves
- Pipe label showing direction of flow
- Pipe Label indicating fluid temperature Hot(Red), Cold(Blue)
- Pipe Label showing what type of Heat Transfer Fluid and/or glycol mixture ratio
- Tank Bypass/isolation valve labels

Common Installation Violations

- System missing labels.
- Dissimilar metals in direct contact promoting galvanic corrosion.
- Missing, damaged or compromised pipe insulation exposing pipe to environment.
- Missing or incorrectly installed tank Pressure and Temperature emergency relief valve discharge pipe.
- Inadequate piping support.
- System pressure is below standard operating levels.

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Small Wind Technology

Technology Requirements

Small Wind turbine technologies that have achieved and maintain certification through the Small Wind Certification Council (ICC-SWCC) shall be program eligible. The table of currently certified eligible turbines can be found at: https://smallwindcertification.org/certified-turbines/

Estimated Production Requirements

Estimated annual electricity generation for wind energy projects must be made using a bin analysis method, such as NREL's WindCAD model or an equivalent tool that combines a wind speed probability distribution with a wind turbine power curve and includes relevant adjustments for local terrain, vegetation, and turbine operational characteristics. Key inputs shall include:

- Wind Speed: Annual mean wind speed shall be obtained from a reputable data source with a minimum spatial resolution of 2.5km x 2.5km
- Anemometer Height: The reference height accompanying the annual mean wind speed. Standard heights include 30m, 50m, and 80m
- Wind Shear: The wind shear is used to adjust wind speeds to match the proposed tower height and reflect, generally, how rough the local terrain is. Commerce RI recommends the following wind shear values based on general nearby terrain:
  - Grass: 0.15
  - Cropland/agricultural: 0.22
  - Scattered trees and hills: 0.29
  - Sparse forest/buildings: 0.34
  - Dense forest/urban setting: 0.44
- Tower Height: The proposed height of the tower
- Adjusted Hub Height: The anticipated hub height of the wind turbine, less the mean canopy height, where mean canopy height is the average height of densely packed obstructions within 10 rotor diameters of the tower location. For example, a 140ft tall tower surrounded by 40ft average canopy height forest would have an adjusted hub height of 100ft. Adjustments to canopy height based on packing density may be made at Commerce RI's discretion.

Commerce RI also recommends including a wind rose, to indicate the directionality of the site wind resource.

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Installation Requirements

All wind energy projects must be installed per Article 694 Wind Electric Systems of the current adopted edition of the National Electrical Code (NEC), as well as all relevant equipment installation instructions and engineering specifications. In addition, Commerce RI has the following specific requirements:

- The bottom of the rotor swept area must be at least 30ft above all surrounding obstructions within 500ft of the tower base
- Applicants seeking grant funding for wind energy projects installed on parcels less than 5 acres in size shall include signed letters of support from all abutting neighbors as attachments to the grant application. These letters must indicate that neighbors have been made aware of all possible acoustic and aesthetic impacts and have no opposition to the proposed project.

Common Installation Violations

- Wind energy projects are frequently sited incorrectly with relation to the available site wind resource. It is important to use the most accurate wind data possible and to position the wind turbine to minimize obstructions to wind flow. Though this is particularly important in the windward direction, obstructions downwind of the wind turbine can also negatively impact the available wind resource.
- All towers and associated equipment must be properly grounded in accordance with NEC 694.40 to minimize the risk of lightning strikes and prevent electrolytic corrosion of tower components.

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Anaerobic Digestion

Estimated Production Requirements

Installers shall comply with the following production/yield validation methods:

Biogas production estimates will be conducted using the following calculation, unless REF approves an alternative method.

$$Annual\,Biogas\,(ft^3) = \frac{A \times B \times C \times D \times E \times 365\,days}{F}$$

Where:

A	Number of animals (Agricultural) or gallons of influent per day (industrial)
B	Pounds of organic material per day
C	Percentage of organic material collected in influent (less spillage and other losses)
D	Digester efficiency
E	COD[1] conversion factor (ft^3 methane per pound of organic matter)
F	Percent methane in biogas

Because the energy production from anaerobic digestion is highly dependent on feedstock, operating conditions and selected digestion process, the feedstock to the AD system should meet the following values for methane gas production:

Methane Gas Production by Feedstock*

Feedstock	Total Solids (%)	CH_4 Yield (ft^3 per pound)
WWTP sludge	**	**
Livestock manure	3-12	0.224-0.288
Food waste	10-30	0.962-1.754
Organic MSW	15-35	0.8-1.515

[1] Chemical Oxygen Demand is a measure of the amount of oxygen required to aerobically digest a substance into CO_2 and H_2O and is used to measure the heat content available from the reverse reaction converting methane and oxygen into water, carbon dioxide, and energy.

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* adapted from Cenex, June 2009

** For WWTP Sludge the following table applies:

Feedstock	CH_4 Yield (f^3 per pound volatile solids)
Primary Sludge	5-6.25
Secondary Sludge	3.03-3.846

* adapted from IEA Bioenergy, Bachmann et al., 2015

Biogas generation shall be converted into energy savings metrics such as electricity (kWh) or natural gas (therms) savings. Ultimately, the energy savings to be evaluated will be driven by a range of factors but the primary output, biogas, will be converted to the appropriate units for evaluation purposes.

The efficiency of the overall AD system depends on the selected energy conversion technology. The selected technology energy efficiency values must fall within these ranges noted in the table below, unless the applicant can supply sufficient justification for an alternative assumption:

Technology	Net Electrical Efficiency		Net Thermal Efficiency		Size Range kW
	Range %	Typical %	Range %	Typical %	
Internal Combustion Engine	25 – 45	33	40 – 49	40	50 – 5K
Internal Combustion Engine – Lean Burn		37			
Gas Turbines	23 – 36	30	40 – 57	40	250 – 250K
Microturbines	24 – 30	27	30 – 40	35	30 – 250
Steam Turbine	20 – 30	25	20 – 45	45	500 – 1,300K
Stirling Engine	25 – 30	27	45 – 65	60	1 – 50

Reprinted with permission from the Water Environment Federation, MOP 32, 2009.

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Installation Requirements

Depending on the proposed technology (low or high solid, single stage/multistage, mesophilic, thermophilic), the anaerobic digestion system must be installed in accordance with the manufacturer instructions and design engineer specifications.

- For the design of the digester and gas components, installer shall provide adequate safety measures and install components in accordance with standard engineering practice for handling a flammable gas. Safety and best practice standards should comply with NRCS Practice Standard 366, Anaerobic Digester[2], EPA guidelines and applicable permitting requirements[3].
- An owner's manual of operating and maintenance instructions must be provided to the AD project owner and preferably also posted on or near the AD project. The owner's manual should include, at a minimum:
    - Manufacturer's specifications, serial numbers, and warranty policies
    - Proper loading rates of the digester and total solids content of the influent
    - Operating procedures for the digester
    - Description of the planned startup procedures, normal operation, safety issues, and normal maintenance items
    - Instructions for safe use and flaring of biogas

Owners must be provided with, at minimum, a basic training orientation that includes maintenance instructions, troubleshooting, meter reading, and reporting instructions.

System Requirements

All installations must follow the most **current adopted edition of the National Electrical Code (NEC)** with the following additions as noted below. In all cases where third-party guides/handbooks, or other materials contradict the most current edition of any local, state, or federal code, the applicable code shall take precedence over such materials.

- Installer shall measure, track, and document the feedstock type and quantity used in the digester design. Digester design must take into account varying feedstock properties. Depending on the system design, extraneous material may need to be removed, reduced, or otherwise handled.

[2] https://www.nrcs.usda.gov/sites/default/files/2022-08/Anaerobic_Digester_366_CPS_Oct_2017.pdf
[3] https://www.epa.gov/agstar/guidelines-and-permitting-livestock-anaerobic-digesters

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- Digester cover, materials, anchorage, and appurtenances shall be designed to capture and convey biogas to the gas collection system. The digester cover and materials shall meet the requirements of NRCS Practice Standard 367, Waste Facility Cover[4].
- Above or below grade tanks must be equipped with an overhead exhaust/ventilation system to capture gaseous emissions and route them to an odor control system.
- All odorous areas should be vented to appropriate abatement. Acceptable abatement treatments include: biofilters, carbon filters, chemical scrubbers, and thermal oxidizers.
- Emission Controls:
    - Nutrient Management Plans must account for how all waste components will be utilized. All participating farms must follow a nutrient management plan that complies with the 2015 NRCS 590 Nutrient Management Standard.[5]
    - Installers or operators should implement an environmentally responsible digestate management plan.

Installers must install and maintain a gas meter and provide measurements of total biogas produced, including the amount of methane produced[6]. The amount of methane content in biogas my vary, but typically ranges from 60%-70%.

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[4] https://www.nrcs.usda.gov/sites/default/files/2022-09/Roofs_And_Covers_367_CPS.pdf
[5] https://www.nrcs.usda.gov/sites/default/files/2024-01/FY2024%20Practice%20User%20Guide.pdf
[6] An example of one meter that may be suitable for automatic methane monitoring:
Methane & CO2 Meter