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CARIBBEAN CENTRE FOR RENEWABLE ENERGY & ENERGY EFFICIENCY
AN INSTITUTION OF CARICOM

Building Codes & Inspection for Solar PV

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IRRP
INTEGRATED RESOURCE AND RESILIENCE PLANS

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Codes

- If not correctly installed, commercial solar PV systems can cause damage to roof-tops, present serious hazards to beneficiaries and 3rd parties due to high voltages and currents and condition of panels always generating in sunlight. Ground mounted systems carry the same risks.

- Codes are therefore a preventative measure for system failures that could otherwise pose a hazard to life and property.

- SPV installation requires more than one type of code or specification for general safety.

- Inspections for compliance are then done against such codes or specifications.

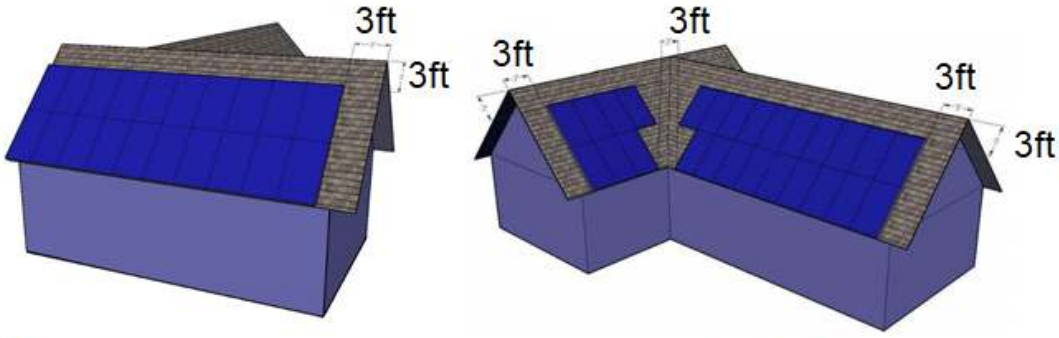
Building Related Codes

- Many of the building specific codes in the Caribbean do not incorporate grid-integrated solar PV into design, though under consideration.

- Various international standards can therefore be used as proxy for safe building integrated SPV systems and inspection procedures.
  - ***International Building Code (IBC) - article 1503.2*** *and* ***article 1507.2.9*** *make provisions for ensuring water proofing after roof penetrations.*
  - ***IBC - article 1509.7.2*** *requires rooftop-mounted PV systems to not diminish fire classification of a roof system.*
  - ***IBC - section 3403*** *requires that solar mounted solar PV systems not compromise the structural integrity of the original roofing structure*. (In some cases a Structural Integrity Assessment [SIA] would be needed followed by structural reinforcement).

Building Related Codes

- ***International Fire Code (IFC)*** *-* ***article 605.11.3.2.1*** *and* ***article 605.11.3.2.4*** *makes provisions for firefighters to access roofs and conduct ventilation operations by creating ft pathway for firefighters and leaving clearance from the apex to 3 ft below the ridge for fire department ventilation operations.*



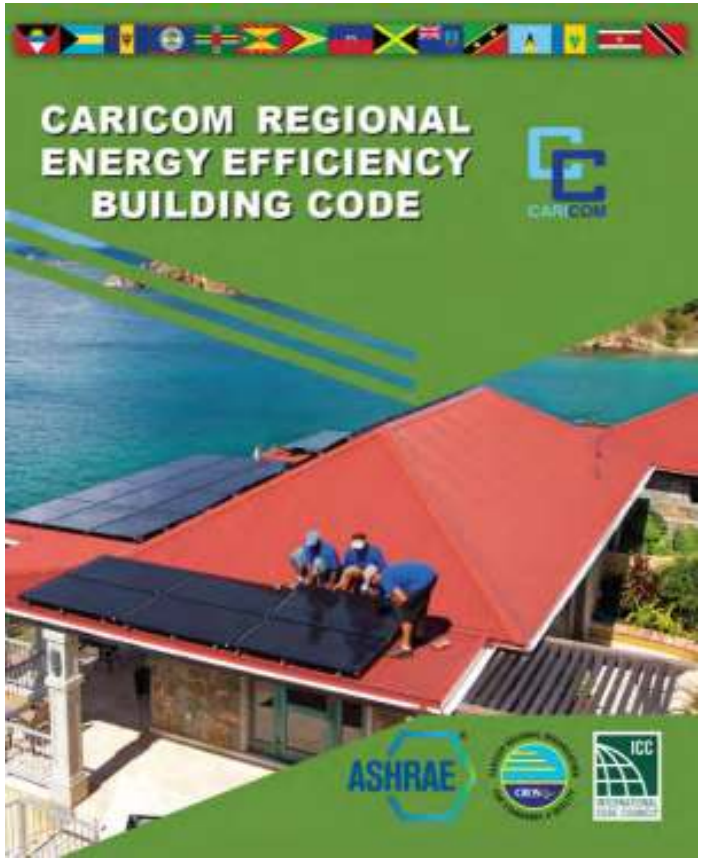
https://www.solarpowerworldonline.com/2018/04/know-your-codes-for-solar-mounting/

- ***National Electrical Code (NEC) 690*** *defines electrical safety requirements for PV systems including.*

Building Code

- **CARICOM Energy Efficiency Building Code** provides guidance for new buildings under "*Appendix CA-Solar ready Zone-Commercial*" for commercial roof top under 5 stories (CA 101.1 – 103.8)

- Technical features for inspection include:
  - Mechanical live and dead loads.
  - Conduit Interconnection Pathways.
  - International Fire Codes.
  - Electrical Service Reserved Space.
  - Other.



Electricity Codes

- Electricity Codes cover the guiding principles, operating procedures, and **technical standards** governing operation of the Grid and all interconnected Generating Facilities.

- Electricity **Generation Codes** and **Supply Codes** are part of the inspection tools to protect the grid and assure people safety during normal operations.

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- Against the Codes, pre-commissioning and post-operation inspections can be executed to include end-to end verification of;
  - **inputs** to protective and control systems (breakers, fuses, transformers etc.);
  - correct **processing** of the inputs by protective and control systems and clearance of faults (e.g. anti-islanding systems); and
  - all **outputs** (breaker tripping and initiation, alarms, SCADA and telemetry etc.).

- Process may include physical inspection and testing of hardwired equipment and controls for effectiveness, and operation of software for functionality.

- Visual and programmatic performance testing may be applicable.

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Transformer:

- Adequate insulation, required excitation and resistance level and polarity etc are achieved (verifiable equipment specifications may be required; limited testing).

Safety Equipment:

- Lightening arrestors, breakers and fuses, motorized switches, fireman "switch" should all be in place and operational (sample testing may be done).

Grounding:

- Verification of the plant's correct ground integration and interconnection with the T&D system. Confirmation of grounding method, connection points and rating etc.

System Relay:

- Relay element settings to be calibrated and confirmed at AC connections.

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Cables:

- Confirmation of correct AC and DC cable types, sizes and current/voltage capacities. Cables and enclosures should satisfy appropriate standards (*e.g.10 gauge [AWG] wires*) (possible visible inspection and measurement).

Conduits and External Enclosures:

- Impact, water and UV resistant conduits (possible surface visual inspections).
- Enclosures should satisfy appropriate standards (*e.g. weather resistant **NEMA 3 - 4 – gasketed enclosure; indoor or outdoor; protection against dust and rain***).

Software Protection, Control Logic and Timer Settings:

- Functional testing may be done.

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Inverters:

- Performance tests to confirm parameters and correct grid sensing/responses.

Anti-Islanding:

- Anti-islanding features tested to ensure no leaks to grid during outage or other grid faults (possible live testing).

Fault Indicators:

- Test trips for alarms, switches and light indicators for system faults, breakers etc. (possibly live testing).

Synchronizing Systems:

- Verification of correct parameters for grid synchronizing controls (possible live measurement testing).

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Voltage Phasing:

- System check before delivery of power.

Operational Metering:

Confirmation that generator complies with technical standards, procedure and hardware for the required onsite metering as applicable (onsite inspection).

SCADA Interfacing:

Verification by the utility that the generator meets the requisite technical requirements for connections to the Operator's Supervisory Control and Data Acquisition (SCADA) system outstation in terms of electrical characteristics.

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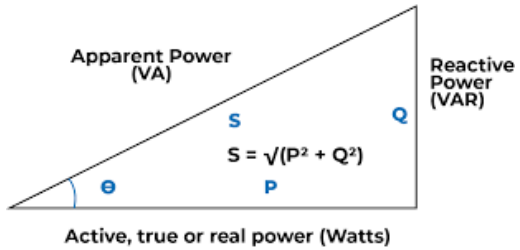
Secondary Load Testing:

- Confirmation of voltages, phasing and currents parameters for grid connection; confirmation of Power (MW), reactive power (MVAr) parameters.



Transfer Trip:

- Testing and verification of the communications software upstream system signaling for disconnect from grid distribution system; also SPV system generation braker responses (possible live testing).

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Similarities of Failed Systems	Similarities of Surviving Systems
Top-down or T-clamp cascading failure of module retention	Appropriate use/reliance on ballast and mechanical attachments
Lack of vibration-resistant connections	Sufficient structural connection strength
Corner of the array overturned due to incorrect design for wind	Through-bolted module retention or four top-down clips per module
Insufficient structural connection strength	Structural calculations on record
Roof attachment connection failure	Owner's engineer with QA/QC program
System struck by debris/impact damage, especially from liberated (dislodged) modules	Vibration-resistant module bolted connections
Failure of the structural integrity of the roof membrane	
PV module design pressure too low for environment	

Source: Rocky Mountain Institute 2020

- Potentially > 571 MW of SPV installed (rooftops, parking canopies, and ground mounted*)(Rocky Mountain Institute 2020)*.
- 2017 Hurricane season events with sustained wind speeds **> 180 mph (290 km/hr.) category 5+** require new standards for exposed SPV systems.
- Inspections will consider the results for failed and intact systems to develop new resilient standards.

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APPENDIX D

PROJECT RESILIENCE CHECKLIST

Pre-Inspection of the Rooftop

- ☐ Roof type
- ☐ Roof age
- ☐ Roof condition
- ☐ Building parapet wall height
- ☐ Drain locations are marked on the planset
- ☐ Skylight locations are marked on the planset
- ☐ Equipment locations are marked on the planset
- ☐ Other obstruction locations are marked on the planset
- ☐ Nearby debris risk (nearby loose items on rooftop, overhanging trees, etc.)

Project Wind Load Inputs

- ☐ Building height assumptions are accurate
- ☐ Project risk category, topographic factor, and exposure category are accurate
- ☐ Project wind speed is accurate
- ☐ Building joist locations and sizes are accurate

Mechanical Fasteners

- ☐ Mechanical fasteners should be utilized in high-wind zones to a minimum acceptable standard (supplied within this document). No ballasted-only systems.

Discussions with the Professional Engineer of Record

- ☐ Does the project engineer have access to the building design calculations to determine capacity?
- ☐ Has the project engineer reviewed the wind tunnel testing of the racking vendor and its application to the project?
- ☐ Has the racking vendor supplied a rigidity assessment specific to their geometry that validates the effective wind areas they assume in the design? If not, the effective wind area should be assumed to be a single module (see Appendix B)
- ☐ Has the project engineer evaluated the worst-case joist loading of the building and not simple array area average loading? (See Appendix C)
- ☐ Has the project engineer verified whether the local wind pressure from the wind tunnel test and project calculations exceeds the module specification for static loading?
- ☐ Has the project engineer verified that the mechanical attachment scheme meets or exceeds the applicable minimum mechanical attachment recommendation? (See Appendix B)
- ☐ Has the project engineer verified that existing practices incorporate all "current mitigations" identified in the FMEA tables? Has the racking vendor performed and supplied their own FMEA to the project engineer?

Hardware

- ☐ Does the project use vibration-resistant hardware? Does the module mount with hardware independent of adjacent modules?

- **RMI Solar PV Resilience Checklist:**
  - Roof-top pre-inspection.
  - Wind load inputs/assessments.
  - Design and specification for mechanical fasteners.
  - Engineering pre-conditions.
  - Resilience of other hardware.

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- Besides hardware and software compliance, the utility or regulator may require **administrative compliance** including:
  - Generation interconnection studies.
  - Schedule and procedures for all tests to be performed periodically by the Generator and System Operator.
  - Emergency plan.
  - Communication and reporting plan.
  - Schedule of responsibilities specifying the ownership and the responsibilities for Operation an Maintenance as jointly agreed by the System Operator and SPV Generator.
  - Generator maintenance schedules.
  - Regulator inspection reports, manufacturer's certifications, municipal approvals etc.

Thank you for your attention.

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