Rooftop Solar Implementation Checklist

From Project Preparation to Operation

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Contents

Introduction

This checklist, derived from the Asian Development Bank's "Handbook for Rooftop Solar Development in Asia," serves as a guide for consultants, Rooftop Solar (RTS) project developers, and others engaged in the process of RTS development. Maintaining the handbook's original structure, this checklist provides a condensed overview of each chapter in a checklist format. Most of the checklist items are presented in "Yes/No" questions format, allowing readers to easily mark their progress and move forward to the next task.
Each RTS project follows the at least five project phases (reflected in each chapter):

1. **Project Preparation**. The foundation of a successful rooftop solar project lies in meticulous project preparation (a.k.a. pre-feasibility). This chapter delves into the site assessment, legal and regulatory considerations, permits and licensing, and financing options, providing stakeholders with a robust framework to ensure the project's viability and sustainability.
2. **System Design**. A well-designed rooftop solar PV system is essential for optimal energy generation and long-term viability. This chapter takes an in-depth exploration of the components of a rooftop solar PV system, site characterization, solar resource assessment, shading analysis, array configuration, module selection, mounting system design, inverter selection, wiring design, system performance assessment, and the critical due diligence process.
3. **Procurement**. Navigating the procurement process effectively is pivotal to realizing a successful rooftop solar project. From preparing bidding documents to evaluating bids and contracting, this chapter offers valuable insights into conducting a transparent, efficient, and legally sound procurement process.
4. **Implementation**. The successful implementation of a rooftop solar project demands meticulous planning and execution. This chapter provides a roadmap for equipment acquisition, permit acquisition, ensuring safety during installation, and thorough testing and commissioning to guarantee that the system operates at peak efficiency.
5. **Operation and Maintenance**. Post-installation, the longevity and efficiency of a rooftop solar PV system relies on consistent performance monitoring, cleaning, diagnostic testing, and preventative maintenance. This chapter underscores the significance of a proactive approach to system maintenance to ensure enduring and optimal energy production.

By following this checklist, you can navigate each stage of rooftop solar development with confidence, precision, and expertise. However, it's essential to acknowledge that this checklist should not be seen as an exhaustive resource on RTS development. As the industry evolves and new standards, codes, guidelines, and handbooks emerge to embrace the latest innovations and trends, I encourage you to delve further into the world of RTS development.

Chapter 1: Project Preparation

The common factors that most people weigh heavily during project preparation are **technical feasibility and cost**. Measuring those two factors will require an evaluation of the following:

1. **The site of the proposed project**,
2. **Legal and regulatory frameworks**,
3. **Permits and licensing**,
4. **Financing options**, and
5. **Implementation arrangements**.

1.1 Site Assessment

A well-conducted assessment of the roof requires developers to answer the following questions:

- Is the roof suitable for installation of solar PV?
- Is the solar resource high enough?
- How much installed capacity could fit on the roof?
- How much energy could that system deliver?

1.1.1 Is the roof suitable for installation of solar PV?

- ☐ Is the roof accessible for carrying out installation and maintenance?
- ☐ Do you have a roof plan (with location, height, slope, and other statures on it)? Has it been assessed?
- ☐ Have the relevant bodies been contacted to receive any special permission required to use and/or alter usage of the roof space?
- ☐ Does the roof need replacement/reinforcement/reconstruction?
- ☐ Has the structural engineer been engaged in a roof assessment? Can the roof be penetrated (won't it have a leakage problem later?)
- ☐ Will the roof be able to bear additional load from the PV system? (static and wind loads)
- ☐ If the roof is sloped/tilted, were the roof trusses been examined on whether they can support additional weight.
- ☐ Does the roof have a warranty?
- ☐ Does the roof have a shadow impact? Are there any objects (trees, buildings, light poles, etc.) that can potentially shade the PV roof area?
- ☐ Will the PV panels negatively affect the aesthetics of the building?
- ☐ Are there any local building restrictions preventing a visible rooftop solar PV installation?

- ☐ Is the roof space planned to be leased to the owner of the rooftop PV system? Did you consult a legal advisor who would be able to confirm whether that type of arrangement is permissible?
- ☐ Do you know the electric load of the system?

1.1.2 Is the solar resource high enough?

- ☐ Have the national solar maps been checked? If National solar maps are not available, from where the solar data have been obtained?
- ☐ Do you have GHI, DNI, GTI, and other solar related meteo data?

1.1.3 How much installed capacity could fit on the roof?

- ☐ How many panels can you fit in the roof? (use the equation from the handbook)
- ☐ Do you have the numbers for the AR (Area of Roof available for installation), CM (Capacity of PV Module), AM (Area of PV Module), and RCR (Roof Cover Ratio)?
- ☐ Has the roof been visited/checked? Are the roof blueprints and photos available?

1.1.4 How much energy could the system deliver?

- ☐ How much is the energy yield of that roof?
- ☐ Did you conduct the simulation using solar software (PVsyst, PV*SOL, Helioscope, etc.)?

1.2 Legal and Regulatory Frameworks

Due to the lack of legal and regulatory frameworks for the promotion of solar energy, as well as the absence of strong institutions for implementing the frameworks, **implementation of the solar projects can face with a huge challenges and major barriers**. That is why **it is important to evaluate whether an adequate legal and regulatory framework exists**. Doing so requires answering the following questions:

- **Are there statements of government support for renewable energy and/or solar energy?**
- **Who are the stakeholders involved in renewable energy development?**
- **How are laws and regulations enforced?**
- **What entities are legally able to develop a renewable energy project?**
- **What are the electrical and grid codes by which the project must abide?**
- **What are the building codes and local zoning laws by which the project must abide?**
- **What kind of incentives are available?**

Summary checklist for Legal and Regulatory Framework

- ☐ **Are there statements of government support for renewable energy and/or solar energy?**

- ☐ What RE policies are present in the country where you plan to install RTS?
- ☐ What RE laws are present in the country where you plan to install RTS?
- ☐ Have you checked IEA's and IRENA's website to see this country's RE laws and policies?
- ☐ Have you involved local agencies and consultancies to give you the relevant information on the countries RE laws, policies, and regulations?

☐ **Who are the stakeholders involved in renewable energy development?**

- ☐ Have you identified each government agency and institution that are somehow involved/affected in/by RE?
- ☐ Have you identified specific tasks of these agencies/institutions stated in local RE law or their enabling regulations?
- ☐ Have you read/checked local RE laws and regulations?
- ☐ Have you identified what agencies/entities handle what permits?
- ☐ Have you identified whom you should approach for specific inquiries?
- ☐ Does the country have any "one-stop shop" places (*AUTHOR'S NOTE: like ASAN service in Azerbaijan*) for obtaining all of the necessary permits and licenses for renewable energy projects?

☐ **How are laws and regulations enforced?**

- ☐ Have you checked government's enforcing mechanisms (fines or other penalties) related to RE project's non-compliance?

☐ **What entities are legally able to develop a renewable energy project?**

- ☐ Does the country where RTS is going to be installed require an installer/designer/etc. company to have license to do their work in this country?
  - ☐ If yes, does the company who is going to install RTS system have the license for this activity in the country?
  - ☐ If a license is required, but no license is available, does this company have a local partner to do this work?
  - ☐ If they are from another country, are they willing to open their local branch in the country where RTS system is going to be installed?

☐ **What are the electrical and grid codes by which the project must abide?**

- ☐ Does the country have specific electrical and grid codes for Solar PV installation? Were these codes analyzed/read/checked?
- ☐ If no electrical and grid codes for solar PV are available, what codes should our PV system comply with? (these can be related to safety, installation, max. voltage, etc.)

☐ **What are the building codes and local zoning laws by which the project must abide?**

- ☐ What are the national and local building codes? Have you analyzed them?
- ☐ Are there any zoning restrictions? (like visibility of PV panels)

- ☐ **What kind of incentives are available?**
  - ☐ Have you identified local incentives for Solar PV? (like RPS, REC, CER, carbon credits, grants, tax incentives, low-interest loans, FiT, FiP, net metering, etc.)
  - ☐ Have you applied to these incentive programs? Have you used them all?

1.3 Permits and Licensing

- ☐ Have you obtained the following permits and licenses?
  - ☐ Renewable energy developer registration;
  - ☐ Zoning clearance;
  - ☐ Building permit or building renovation permit;
  - ☐ Electrical permit;
  - ☐ Mechanical permit;
  - ☐ Structural permit;
  - ☐ Fire permit;
  - ☐ Environmental impact assessment, or certificate of exclusion thereof;
  - ☐ Renewable energy generation and/or sale license;
  - ☐ Clearance or permit for grid interconnection;
  - ☐ Helipad height clearance permit; and
  - ☐ Activity clearance for transport of materials.
- ☐ Are there any other permits that need to be obtained, except those that are mentioned above?

1.4 Financing Options

- ☐ Have you estimated the net investment cost (cost of the system minus any cost offsets)?
- ☐ How is the project going to be financed: direct purchase or using third-party financing?
  - ☐ If using third-party financing, is it going to be PPA or SLA?

Chapter 2: System Design

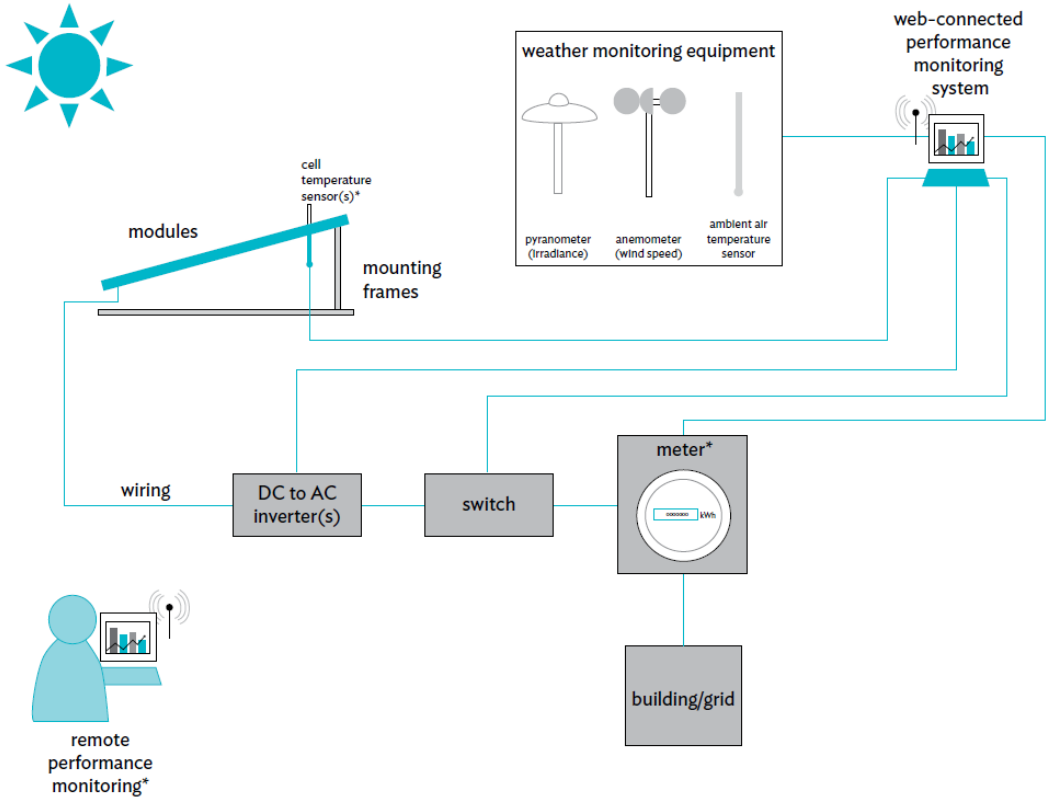
2.1 The Components of a Rooftop Solar Photovoltaic System

Essential components:

- PV Panels
- Mounting frames
- Inverters
- Wiring, switches, and interconnections

Optional components:

- Metering equipment (e.g., smart meter)
- Batteries
- Solar Trackers
- Weather Station
- Performance monitoring software



AC = alternating current, DC = direct current.
* Optional component.
Source: ADB.

Figure 1: Diagram of a Solar PV system (Source: Handbook for Rooftop Solar Development in Asia (ADB)

2.2 On- or Off-Grid Option

No checklist here 😊

2.3 Site Characterization and Assessment

- ☐ Have you passed thought **Site Building Characterization checklist**? Did you **characterize**, **consider,** and **check** the following?
  - ☐ Roof latitude, longitude, elevation, and orientation;
  - ☐ Floor plan of roof deck, with dimensions and total area;
  - ☐ Access to roof for installation and maintenance;
  - ☐ Competing uses of the roof, and proximity restrictions of the solar array from these uses;
  - ☐ Roof plan showing area usable for the solar installation, total calculated usable area, and slope;
  - ☐ Roofing materials, possible mounting connection points, and restrictions to mounting, to aid with selection of mounting method (mounting systems are further discussed later);
  - ☐ Shading analysis, by structures on the roof and nearby structures (detailed later);
  - ☐ Any restrictions for aesthetic purposes;
  - ☐ Specifications of the strength of the mounting system required to:
    - ☐ Comply with building or electrical codes for solar panels, and
    - ☐ Meet wind speed (jet blast) rating requirements for helipads, if present; and
  - ☐ **Structural plans for the building and load capacity of the roof.**
- ☐ Did you check/evaluate the load bearing capacity of the roof?
  - ☐ Did you consider the additional wind/snow loads + load of the PV system (PV panels + mounting structure)
  - ☐ Did you involve structural engineers in this evaluation?
- ☐ Did you conduct structural and seismic analysis of the final design?
- ☐ Have you passed through **Site Load Characterization checklist** (this will help with determining whether the existing electric service can accommodate the PV system)?
  - ☐ Did you get their **average annual electricity consumption**,
  - ☐ Did you get their **typical load profile during working days and weekends**, and
  - ☐ Did you get their **minimum demand**?

- ☐ Have you passed through **wiring and interconnection with the grid** (this will also help with determining whether the existing electric service can accommodate the PV system)?
  - ☐ Did you get their **interconnection location, current-carrying capacity of contacts (in switches), and electrical specifications**,
  - ☐ Did you get their **technical specifications of substation and switch gear**, and
  - ☐ Did you get their **site plan showing locations of substations, conduits, and interconnections, including space available for installing transformers**?

2.4 Solar Resource Assessment

- ☐ What is the size of the system (<100 kW, 100 kW - 1 MW, >1 MW)? Do you need to set up a meteo station for one year/a few months or it's enough to get the data from online sources?
  - ☐ If meteo data collection is necessary, did you consider using **Meteo Data Collection Procedures/Guidelines from NREL**?
- ☐ Did you purchase long term (min 10 years) solar data for initial analysis? (if necessary)
  - ☐ Is purchased data accurate enough (accurate to within –1% and +3% of the World Radiometric Reference)?

2.5 Shading Analysis

- ☐ Did you do shading analysis manually?
- ☐ Did you do shading analysis using 3D rendering software?
  - ☐ Did you collect necessary data/information (location, orientation, and dimensions) about your surrounding?
- ☐ Did you consider the possible future buildings nearby?
- ☐ Is your system shade free from 9 AM to 3 PM?

2.6 Array Configuration

- ☐ What is the tilt of the system? Is it optimized to get the maximum output? If not, what is the reason for this decision?
- ☐ Is the tilt lower than 10 degrees? (it shouldn't be)
- ☐ Did you do the wind load analysis considering the tilt angle and orientation of the system?
- ☐ What is the orientation of the PV modules in the system? If it's not south oriented (180 degrees), why so?
  - ☐ Did you consider the typical diurnal cloud condition?
  - ☐ Did you consider the time of maximum load of the building/facility?

- ☐ Is spacing between panels calculated to avoid inter-row shading? (ideally from 9 a.m. to 3 p.m., in December 21)
- ☐ Do you have limited space available? Did you try to optimize tilt, orientation, spacing to maximize the available space for PV panels?
- ☐ Did you consider aesthetics of the system?
- ☐ Are there any regulations/rules related to aesthetics of PV system? Maybe zoning rules?

2.7 Solar Photovoltaic Module Selection

- ☐ When choosing a PV module technology, did you consider the following factors:
  - ☐ efficiency,
  - ☐ price,
  - ☐ availability in the market,
  - ☐ length and terms of performance guarantee,
  - ☐ form and appearance, and
  - ☐ response to the climatic conditions.

2.8 Mounting System Design

- ☐ What kind of roof does your project have? Is it flat or tilted?
- ☐ Can you penetrate the roof?
- ☐ If using ballast system, should you also add rubber feet under ballast to prevent it from sliding?
- ☐ Is the roof under warranty?
- ☐ Did you coordinate closely with the roofer when designing a mounting structure for that particular roof?
- ☐ If the roof is flat, and the mounting system is a standoff one, is it justified to add additional tilt to the tilted surface (will those extra generated kWh-s justify additional expense on mounting structure)? (it can be calculated to compare the NPVs of two scenarios)
- ☐ Did you coordinate closely with structural engineer during designing a system (so that it can withstand the dead load and wind loads, and that has fewer but stronger attachments to minimize the risk of leaks)?
- ☐ After the installation of the mounting structure, did you conduct a **leak testing**? (NOTE: it must be done BEFORE the modules are installed)
- ☐ Did you consider using BIPV in your project? Can it be used here? Is it justifiable? (NOTE: Some thin film modules also allow for attachment directly to the roofing surface, removing the need for a mounting frame.)

2.9 Inverter Selection

- ☐ Is your grid-connected inverter **compliant with UL 1741, IEEE 1547, or other equivalent local national standards**?
- ☐ Did you consider **local grid code**, electrical codes and the electrical utility when choosing an inverter? Does it have any specific requirements for inverters?
- ☐ Does the chosen inverter:
  - ☐ have the capacity to convert the full output of the solar PV array and,
  - ☐ have the quality of utility-grade electricity for output electricity?
- ☐ When choosing the numbers of inverters, did you consider the five following constraints:
  - ☐ **Reliability**. (One large inverter or several smaller inverters).
  - ☐ **Efficiency**. (Central inverters are more efficient than string ones).
  - ☐ **Solar PV array segmentation and shading characteristics**. (How is the shading state in the site?)
  - ☐ **Space constraints**. (Fewer larger inverters will occupy less total space than several small ones) (NOTE: this is less applicable for RTS systems, but still take this constraint into consideration)
  - ☐ **Environmental conditions**. (Should you locate inverter indoor or outdoor)
- ☐ **Did you calculate the following when choosing/designing a string size and the inverter for the system?**
  - ☐ Maximum input voltage (using the following formulas: $V_{adj,max} = V_{oc} + (T_{STC} - T_{min}) \times T_k V_{oc}$ **and** $N_{s,max} \leq \frac{V_{max}}{V_{adj,max}}$)
    - ☐ Did you find the **historical extreme minimum** air temperature T_{min} for that location? Was the source of information reliable? (was it from national meteorological organization for the weather station nearest to the site)
    - NOTE: Round $N_{s,max}$ **DOWN to the nearest whole number**
  - ☐ Minimum input voltage (using the following formulas: $V_{adj,min} = V_{oc} + (T_{STC} - (T_{max} + T_{cor}) \times T_k V_{oc}$ **and** $N_{s,min} \geq \frac{V_{min}}{V_{adj,min}}$)
    - ☐ Did you find the **historical extreme maximum** air temperature T_{min} for that location?
    - ☐ Did you consider the correct correction value for T_{cor}?
    - NOTE: Round $N_{s,min}$ **UP to the nearest whole number**
    - ☐ Did you consider module's voltage degradation rate in your calculations/estimations?
  - ☐ Maximum input current (using the following formula: $N_{p,max} \leq \frac{I_{min}}{I_{module}}$)

- ☐ Related to the previous calculation check: did the inverter manufacturer provide the **string sizing guidelines** or online programs that perform the calculations for their inverters? Did you use the software to do those calculations?
- ☐ Did you calculate the inverter's maximum numbers of strings in parallel? (using $N_{p,max} \leq \frac{I_{min}}{I_{module}}$)
- ☐ Does the electricity output from the inverter match the **interconnection requirements of the grid** and of the internal power system?
  - ☐ Was the inverter set up to match these requirements prior to shipping and installation?
  - ☐ After the installation, was the on-site performance of the power inverter certified by an international independent third-party certification body (TÜV, UL, or any other local certification body?)

2.10 Wiring Design

- ☐ Did you find and check all parts of **building and electrical codes** related to solar PV of the location where you're going to install RTS?
- ☐ Does your wiring match the properties of inverter? (min/max voltage, power, etc.)?
- ☐ Have you made sure that your wires and cables are sized to **minimize losses and ensure electrical safety**?
- ☐ Are your wires rated to withstand the high ultraviolet radiation and heat? (and how can you prove it? (certifications, standards, etc.?))
- ☐ Did you make a proper grounding? Is all equipment connected together to be directed to a **single grounding point**? (this is used unless it is specified differently in the local electrical codes)
- ☐ Did you install **lightning protection** on your system? Surge protectors? Lightning arresters? Lightning rods? Special grounding?

2.11 System Performance Assessment

- ☐ What is the DC System size of your system?
- ☐ Do you have GHI data? What about GTI data? Annual, daily, or hourly?
- ☐ Have you estimated all the possible individual derate factors to calculate derate factor for the whole system? Minimum, it should include the following:
  - ☐ Shading;
  - ☐ Reflection;
  - ☐ Temperature;
  - ☐ Soiling;
  - ☐ Mismatch and wiring;
  - ☐ Inverter;
  - ☐ Module degradation;

- ☐ Grid availability.

2.12 Due Diligence

- ☐ Was the designed system passed through due diligence?
- ☐ Did your due diligence analysis/report include the following items:
  - ☐ Evaluation of Solar irradiation databases and assumptions;
  - ☐ Evaluation of Material and system losses, including shading analysis;
  - ☐ Evaluation of Electromechanical design as adapted to site conditions:
    - ☐ Sizing of solar photovoltaic modules;
    - ☐ Sizing of balance of system;
    - ☐ Wiring and/or cabling; and
    - ☐ Support structures.
  - ☐ Evaluation of Annual electrical yield output (kWh/year); and
  - ☐ Evaluation of Techno-financial model (project cash flow analysis, and so on).
- ☐ Was an independent consultant/expert hired to **evaluate the design** of the project?
- ☐ Was an independent consultant/expert hired to **evaluate the financial calculations** of the project?
- ☐ Was an independent consultant/expert hired to **conduct a structural and seismic analysis** of the system?

Chapter 3: Procurement

The **bidding process** typically has the following timeline:

1. Nominate a procurement committee;
2. Publish advance procurement notice;
3. Prepare bidding documents and the bid evaluation criteria;
4. Publish and issue invitation to bid and bidding documents;
5. Hold prebid meeting;
6. Collect queries and requests for clarification, and disseminate responses to bidders;
7. Receive bids;
8. Open and evaluate the technical bids, and clarify as needed;
9. Rank the technical bids and then open the commercial bid, and prepare the final ranking;
10. Select bidder;
11. Negotiate contract;
12. Conduct independent evaluation;
13. Revise design; and
14. Sign contract.

3.1 Preparation of Bidding Documents

- ☐ Is your project large enough to go through a bidding process?
- ☐ Have you prepared at least the following list of bidding documents?
  - ☐ Instructions to bidders;
  - ☐ Bid datasheet;
  - ☐ Evaluation and qualification criteria;
  - ☐ Bidding forms;
  - ☐ Technical outline;
  - ☐ Draft contract;
- ☐ Is your technical outline (a.k.a. SoW) detailed enough? Does it include information on:
  - ☐ required licenses,
  - ☐ relevant sections from electrical codes,
  - ☐ renewable energy policy and regulation, and
  - ☐ meteorological data

3.2 Pre-bid Activities

- ☐ Did you hold a Q&A session for your tender?
- ☐ If yes, did you distribute (in writing) information from this session?

- ☐ Was it done within a reasonable amount of time to give bidders enough time to review the information prior to submitting bids?

3.3 Bid Evaluation

- ☐ Did you choose the **correct bidding method** for your tender (consult with procurement specialist)?
- ☐ Did you correctly follow the "**Steps for evaluating the technical and the price proposals**"?
  - ☐ Are all technical and financial aspects in compliance with the requirements stated in the bidding document?
  - ☐ If a bid proposal requires clarifications, did you request the bidder to submit necessary information or documentation?
  - ☐ Does the bidder meet the eligibility and qualifying criteria specified in the bid documents?
  - ☐ Did you compare bids based on the scoring you gave them in each phase of bid evaluation?
  - ☐ After technical evaluation, did you receive an internal approval?
  - ☐ Did you notify the bidders about the results of the tender?

3.4 Contracting

- ☐ Did you use local legal counsel to draft and review contracts?

Chapter 4: Implementation

4.1 Equipment Acquisition

- ☐ Did you check all the **local importing rules and regulations, and import taxes**?
- ☐ Did you prepare a **proper and secure storage space** for the RTS system component?

4.2 Obtaining Permits

- ☐ Is obtaining **permits and clearances** the responsibility of the contractor? If yes, did you make sure they got all the permits? (consult with the first chapter, for learning what permits is necessary (*AUTHOR'S NOTE: by this time you should have already found the list of all permits and licenses that you need to obtain for RTS project*))
- ☐ Did the building owner provide the contractor with the necessary documents and information to obtain the permits?

4.3 Ensuring Safety

- ☐ **Did all personnel undergo safety training? (IMPORTANT)**
- ☐ Are working personnel wearing all suitable **personal protective equipment**?
- ☐ Is working personnel wearing **anchoring equipment at all times**? (like hard hat, covered shoes, gloves, sunglasses, etc.)
- ☐ While working on the roof, is working personnel **clipped into a secure point** at all times?
- ☐ Is the licensed electrician who understands DC systems and the local electrical code always present on the site and performs electrical work?
- ☐ Are all electrical operations fully understood?
- ☐ Are all installers qualified to do the electrical work?
- ☐ Were the panel and inverter's installation instructions thoroughly analyzed and understood? Do the installers follow these instructions?
- ☐ How is the **weather during the planned construction day**? Is it windy or rainy (avoid windy and rainy days as much as possible)
    - ☐ Did you check the weather forecast for several days ahead (to ensure good weather during the entire installation period)
- ☐ Do the installation personnel wears jewelry? (NOTE: they should not wear any jewelry during the installation of RTS system)
- ☐ Do you have a **fire extinguisher, a first-aid kit**, and a hook or cane available when performing work around energized equipment?
- ☐ Are there any flammable gases or vapors present in the vicinity of the installation site?

- ☐ Were basic safety instructions considered during the installation of the RTS system?

4.4 System Installation

- ☐ Were qualified professionals (civil, electrical engineers and others) involved in the installation of the RTS system?
- ☐ Is the construction manager involved in **supervising the daily construction** of the RTS system?
- ☐ Did the building owner engage one of their own engineers or a qualified third party to oversee the installation?
- ☐ Did the installer follow the proper installation procedure?
- ☐ Was the proper **construction/installation plan** developed?
- ☐ If the weather and monitoring system was included in the project, was it properly installed?

4.5 Testing and Commissioning

- ☐ Was the **local Testing and Commissioning procedures** used?
- ☐ Was **IEC 62446** used for proper Testing and Commissioning procedures?
- ☐ Was EACH component of the RTS system visually inspected and tested?
- ☐ Were representatives of both the developer and the building owner attended during the testing and commissioning?
- ☐ Are the inspectors, who are involved in the testing and commissioning process, verified and accredited to do those testing (for construction part and for electrical part)?
- ☐ Did inspector check and verified the following:
  - ☐ All components have been completely and correctly installed,
  - ☐ All components have been properly labeled,
  - ☐ All components can withstand weather exposure, and
  - ☐ All components are included in the as-built plans,
  - ☐ The system is aesthetically acceptable.
  - ☐ Module string polarity (for each string)
  - ☐ Open-circuit voltage (Voc) and short-circuit current (Isc).
  - ☐ Grounding (ground resistance)
  - ☐ Insulation resistance testing (to verify that no currents are leaking between the conductors and earth) (it is also known as “Megger testing” or “hipot”)
  - ☐ Component functionality (checking and testing all system components like switch gear, controls, and inverters, including inverter synchronization and anti-islanding)
- ☐ Was the testing conducted in a good weather, with a good amount of irradiance?

- ☐ Was the system observed to work properly over several days (that it automatically disconnected during sunset and reconnection and synchronize during sunrise)?
- ☐ Once commissioning is over, did the developer deliver as-built plans to the building owner? (it should include at least the following:)
    1. general system data, including rated power, number and type of modules and inverters, contact information, and project dates;
    2. wiring diagram;
    3. datasheets for modules, inverters, and any other major components;
    4. mechanical design of the mounting system;
    5. operation and maintenance documentation; and
    6. test results and commissioning report.

Chapter 5: Operation and Maintenance

5.1 Performance Monitoring

For performance monitoring:

- ☐ Did you take data from data logged in inverters, switches, and meters?
  - ☐ If the RTS system has a data acquisition system, did you use it for monitoring the performance of the system?
- ☐ Do you compare the power production of the system/each string to the design range of values (to find the fault)
- ☐ If PPA is used, do you submit a report to the building owner once a month summarizing the energy in kilowatt-hours (kWh) delivered to the facilities?
- ☐ Do you regularly check the following performance indicators?
  - ☐ Net AC kWh production
  - ☐ AC electricity generation effectiveness (ACEGE)
  - ☐ Performance ratio (PR)

5.2 Cleaning

- ☐ Do you clean the PV panels often enough?
- ☐ Do you adjust your cleaning schedules based on the anticipated weather, nearby construction, or other circumstances that have soiling impact to your system?
- ☐ Do you remove algae and other plant life that build up on or under the panels?

5.3 Diagnostic Testing and Preventative Maintenance

- ☐ Do you conduct regular conduct checks/diagnostics and preventive maintenances measures in an annual, biannual, or quarterly periods (to ensure that all elements of the system are performing properly)?
- ☐ Are all safety procedures followed when conducting testing and maintenance?
- ☐ Is the maintenance team large enough (several engineers and technicians, depending on the size of the system) and have enough time (several days, depending on the size of the system) to conduct all the necessary testing and maintenance procedures?
- ☐ Did you prepare a checklist/procedure for the Diagnostic Testing and Preventative Maintenance?