ICLEI Local Governments for Sustainability

100% RENEWABLES CITIES & REGIONS ROADMAP

Supported by:

Federal Ministry for Economic Affairs and Climate Action

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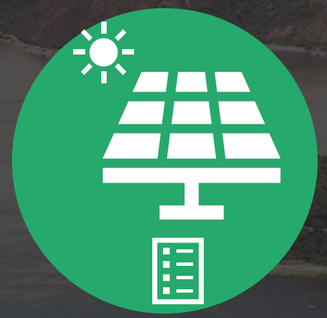
on the basis of a decision by the German Bundestag

Capacity Building Module: Solar Energy Basics & Solar Photovoltaic Systems

CHAPTER 3:

Solar PV Project Development

CONTENTS



Project Development

Design & Engineering

Procurement, Operation & Maintenance

STAGES OF PV PROJECT DEVELOPMENT

1. IDENTIFICATION

Identify projects based on LRG's needs

2. EXPERT ENGAGEMENT

Engage the right experts to assess options

3. ASSESS OPTIONS

Quantify the benefits of each option and assess which options are affordable. Identity a preferred option.

4. EARLY PROJECT FINANCE

Secure financial support from LRG and National Government. Engage with other development partners.

5. DEMONSTRATE FEASIBILITY

Conduct detailed technical and financial studies to conclude on affordability

6. SECURE FUNDING

Formalize funding commitments with legal contracts or via LRG/NG budgets

7. PROCUREMENT

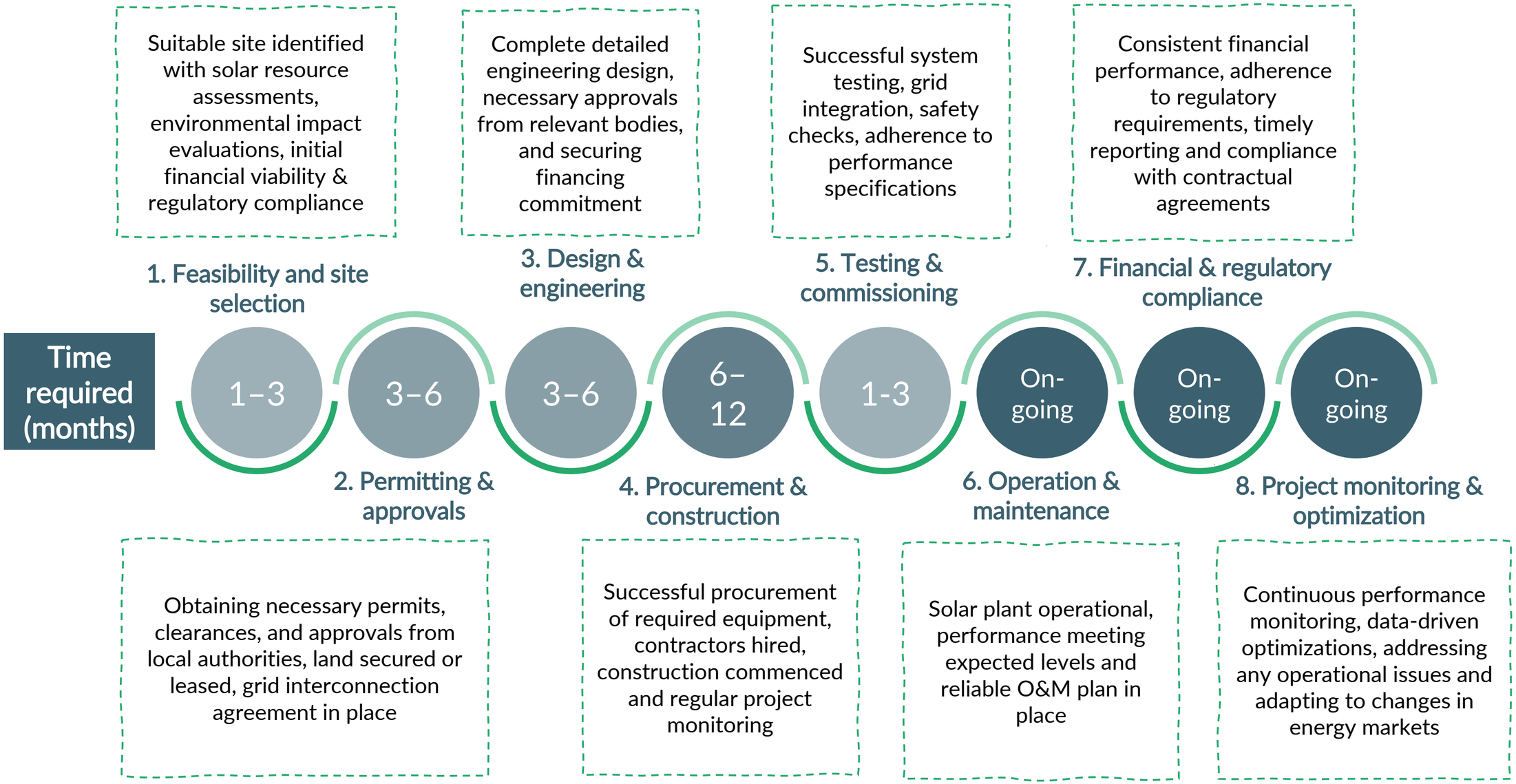
Appoint private sector partner (if PPP) via tender process. Procure EPC contractor if public owned, and SLA partner if operated by the private sector.

8. MONITORING

Monitor performance of private sector against contractual obligations. Report on KPIs.

Engineering, procurement, and construction (EPC) stages >

EPC STAGES OF SOLAR PV PROJECT DEVELOPMENT

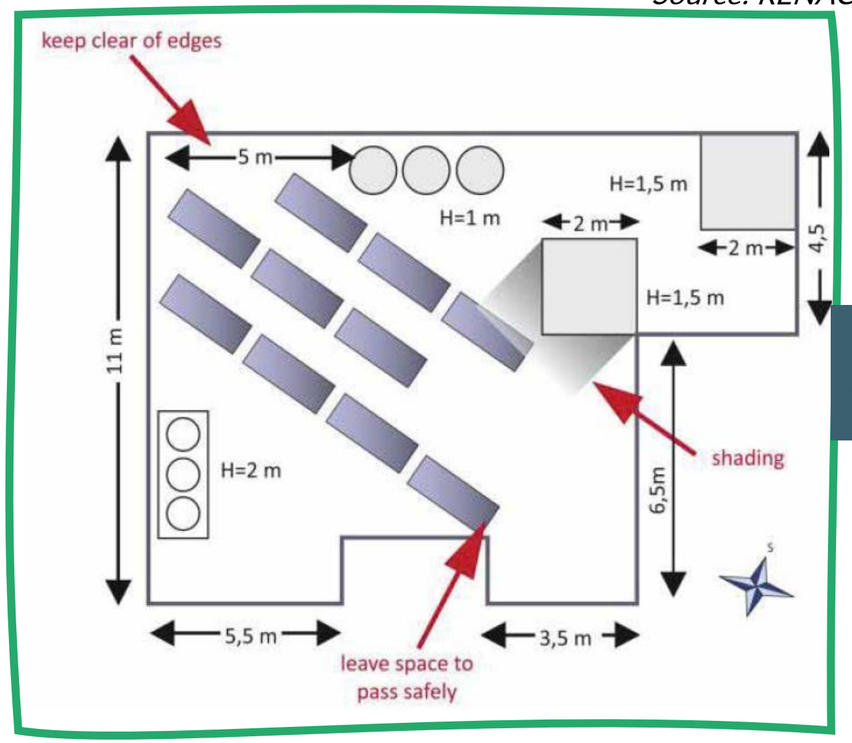


1. FEASIBILITY & SITE SELECTION

Key steps involved in a site survey:

- Gather customer information
- Use satellite or aerial data
- Take roof measurements
- Perform a shade analysis
- Evaluate the electrical system
- Determine solar panel location & layout
- Create a system design
- Creating proposal

Source: RENAC



Shading analysis

Possibility for rooftop installation

Possibility for ground mounted PV installation

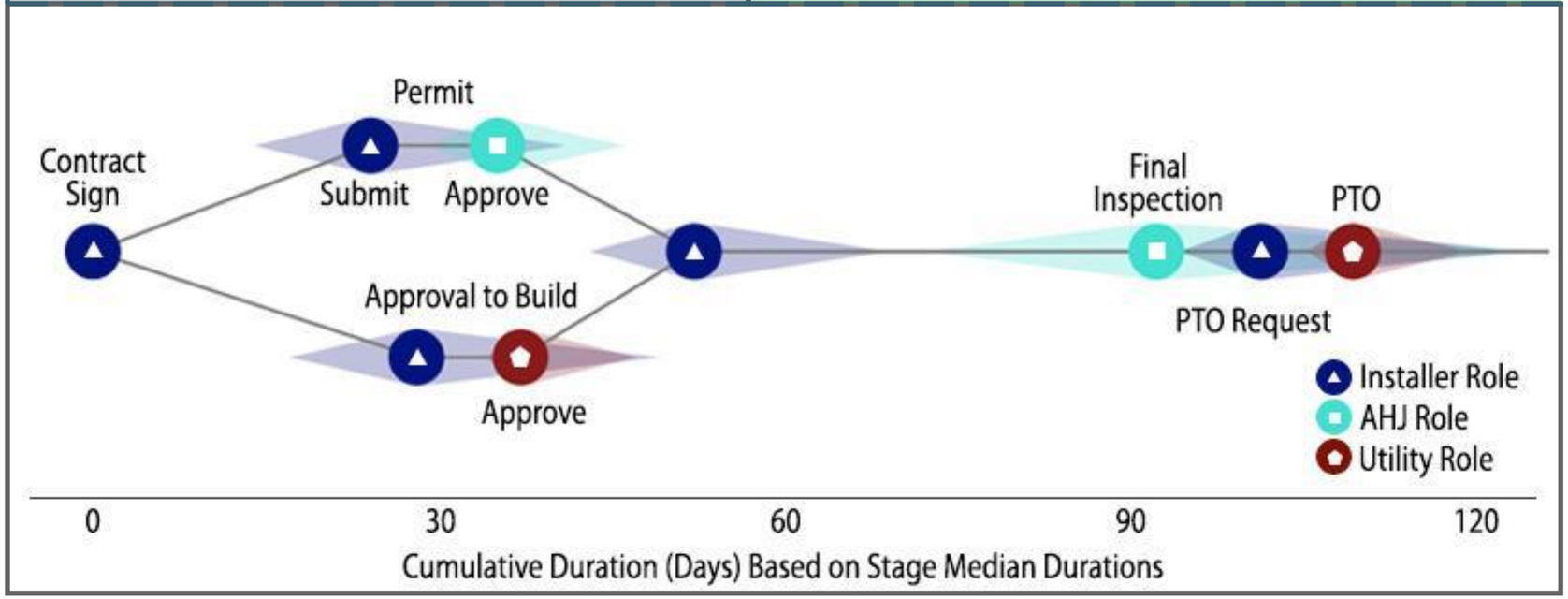
Source: Google maps – Germany 2023

Possible installation sites for rooftop and ground mounted PV

2. PERMITTING & APPROVALS

The permitting and approvals stage is essential to ensure the safe, legal, and responsible deployment of solar PV systems.

It promotes regulatory compliance, environmental protection, community support, and economic development while contributing to long-term sustainability and resilience.



Source: https://www.nrel.gov/solar/market-research-analysis/permitting-inspection-interconnection-timelines.html

3. DESIGN & ENGINEERING:

Why is solar resource assessment important in project planning?

The energy output of solar technologies varies based on the availability of solar resources, sometimes requiring storage systems to stabilize output and meet demand.

Investment decisions for solar systems consider factors such as life cycle cost and levelized cost of economics.

Understanding the properties of radiation resources is crucial for optimizing solar energy utilization.

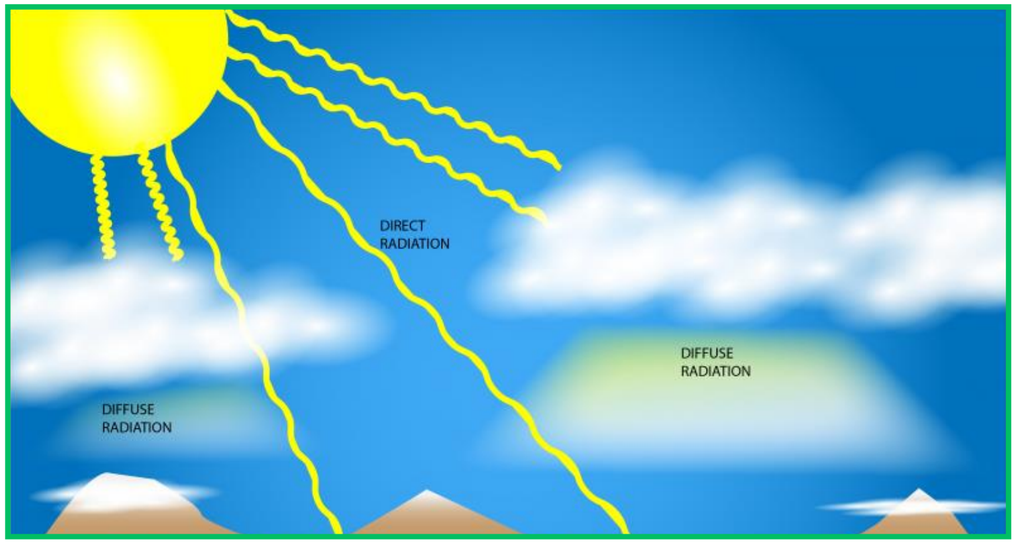
Solar Resource Assessment

- Direct normal irradiation, DNI
- Global horizontal irradiation, GHI
- Diffuse horizontal irradiation, DHI

A. Ground based measurement

B. Satellite derived data

A. GROUND BASED MEASUREMENT OF SOLAR RESOURCES



Source: https://www.essearth.com/solar-irradiance/

Direct **Diffuse** **Global**

Pyrheliometer

Pyranometer

Ground based measurement

Ground measured data is the most accurate input for system design

Large scale PV power plants install ground measuring stations for evaluation

B. SATELLITE-DERIVED SOLAR RESOURCE DATA

Global insights:

- Satellite data provides global solar information, allowing assessments of remote regions.

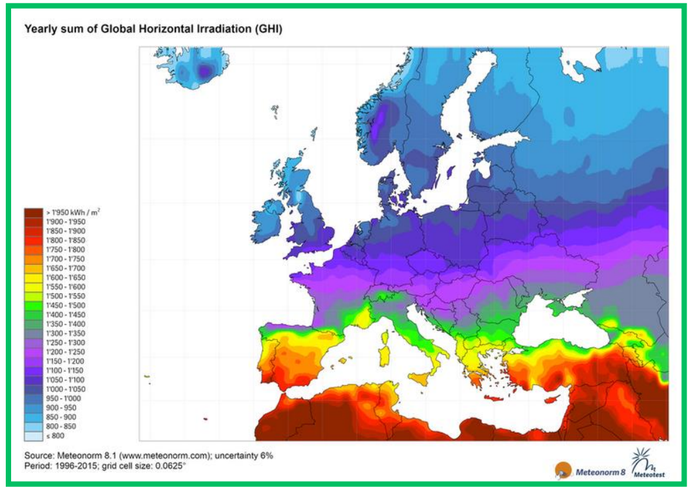
Timely updates:

- Regular updates provide current solar potential, which is crucial for dynamic energy markets and decision-making.

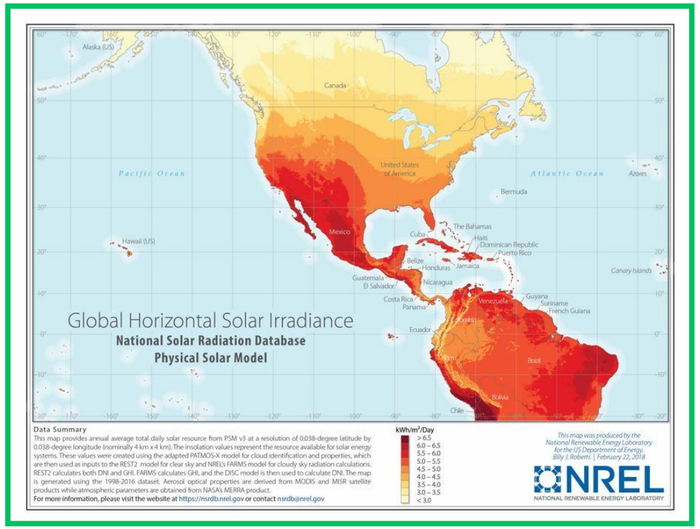
Software integration:

- Satellite data blends with simulation software (PVGIS, NREL, Meteonorm, PV*sol, Pvsyst), helping streamline solar project design, operation, and assessments.

Meteonorm – Annual data



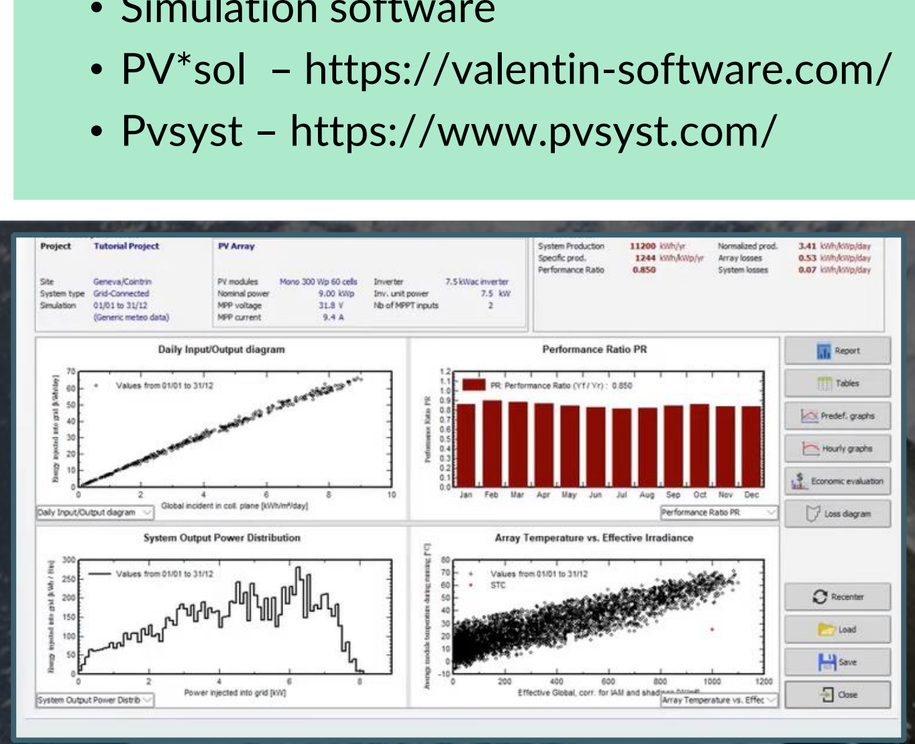
NREL – Solar radiation database



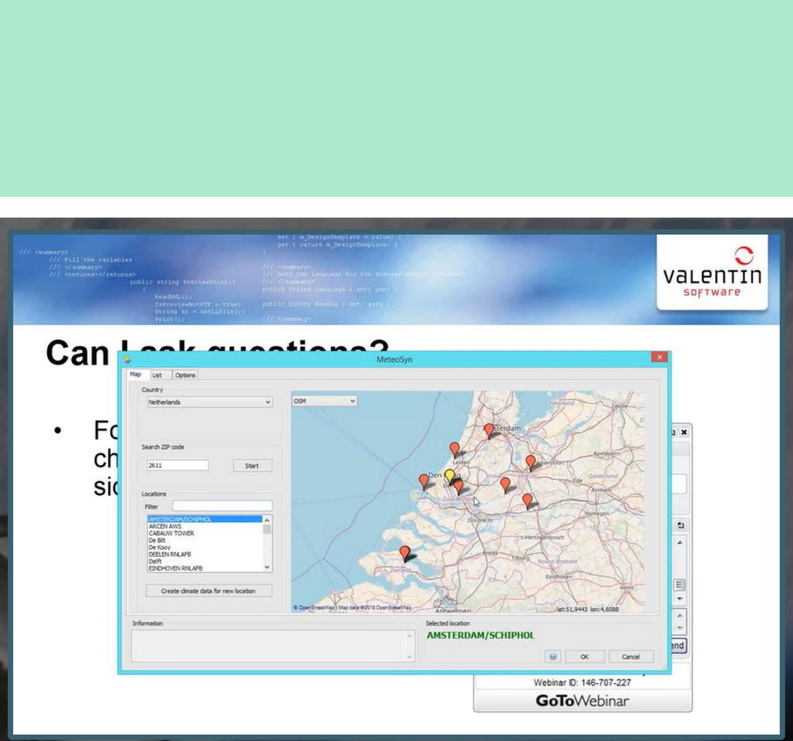
https://www.nrel.gov/gis/solar-resource-maps.html

B.1 SOURCES OF SATELLITE-DERIVED DATA

- PVGIS – https://re.jrc.ec.europa.eu/pvg_tools/en/
- National Renewable Energy Laboratory, USA – https://www.nrel.gov/gis/solar.html
- NASA - Horizontal data only – https://asdc.larc.nasa.gov/project/SSE
- Meteonorm (digital database) – https://meteonorm.com/en/buy#datasets-maps
- Simulation software
- PV*sol – https://valentin-software.com/
- Pvsyst – https://www.pvsyst.com/



PVsyst software



PVSOL (Valentin) software

B.2 HOW TO GET RELIABLE METEOROLOGICAL DATA?

Ground measurement:

- Pyranometer
- Pyrheliometer
- Solar tracker system
- Reference solar cell
- Data logger

Satellite data measurement:

- Equatorial
- Polar
- Geostationary

Quality checked **ground measurements** to gain highly accurate data

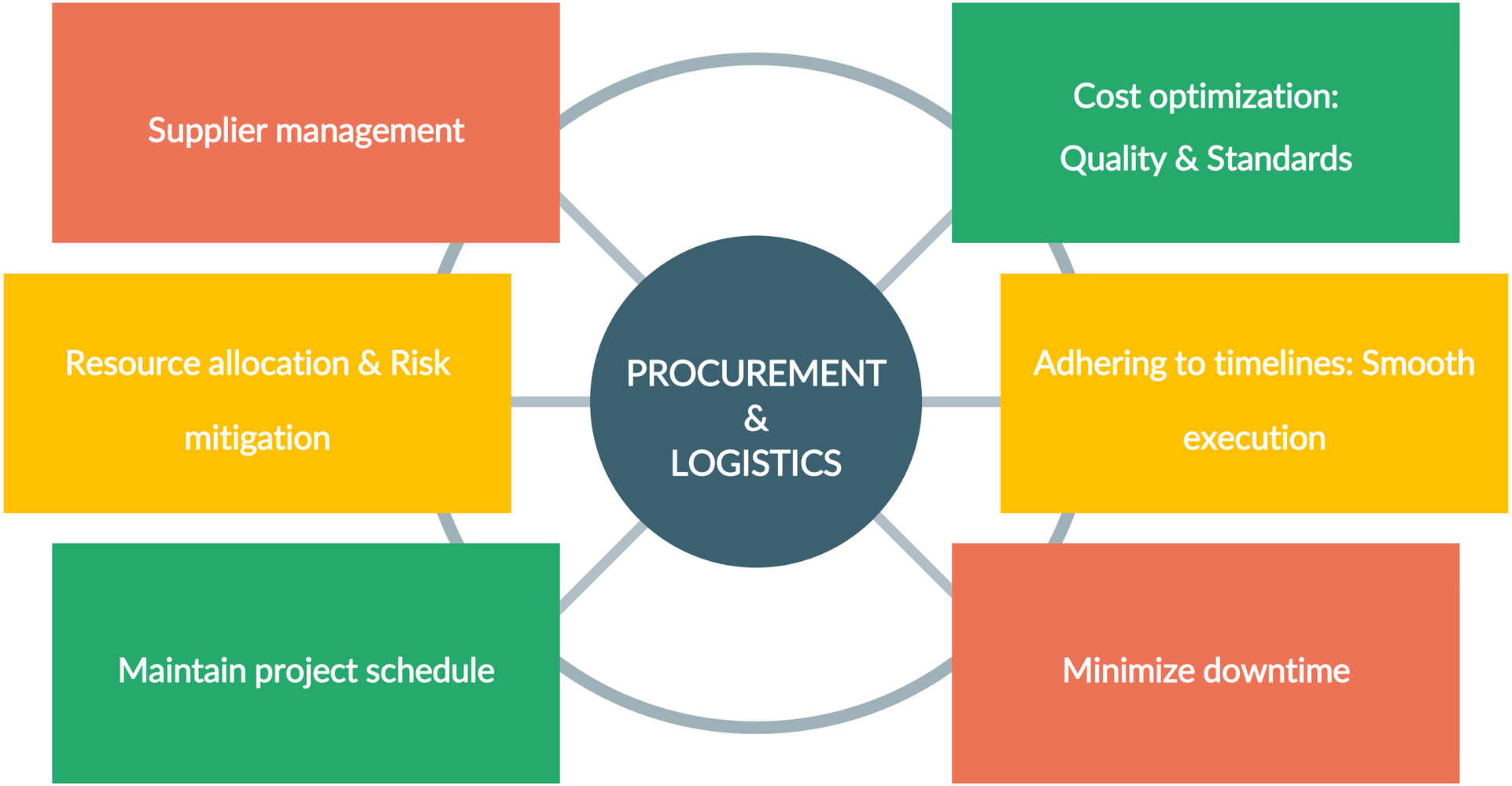
Validation of satellite data with ground measurements

Derivation of irradiation from **satellite data** to get:

- Spatial distribution
- Long term time series

Result:
Accurate hourly time series, irradiation maps and long-term annual mean

4. PROCUREMENT & CONSTRUCTION



Process oriented images + review

PROCUREMENT & LOGISTICS FOR PV

Procurement required for:

- Road building
- Foundation
- Transport and installation
- PV power plant (PV modules, inverters, cables, etc.)
- Grid-connection
- Compensatory measures
- Remote monitoring system
- Others (construction management, etc.)

Question: One EPC contractor or different partners?

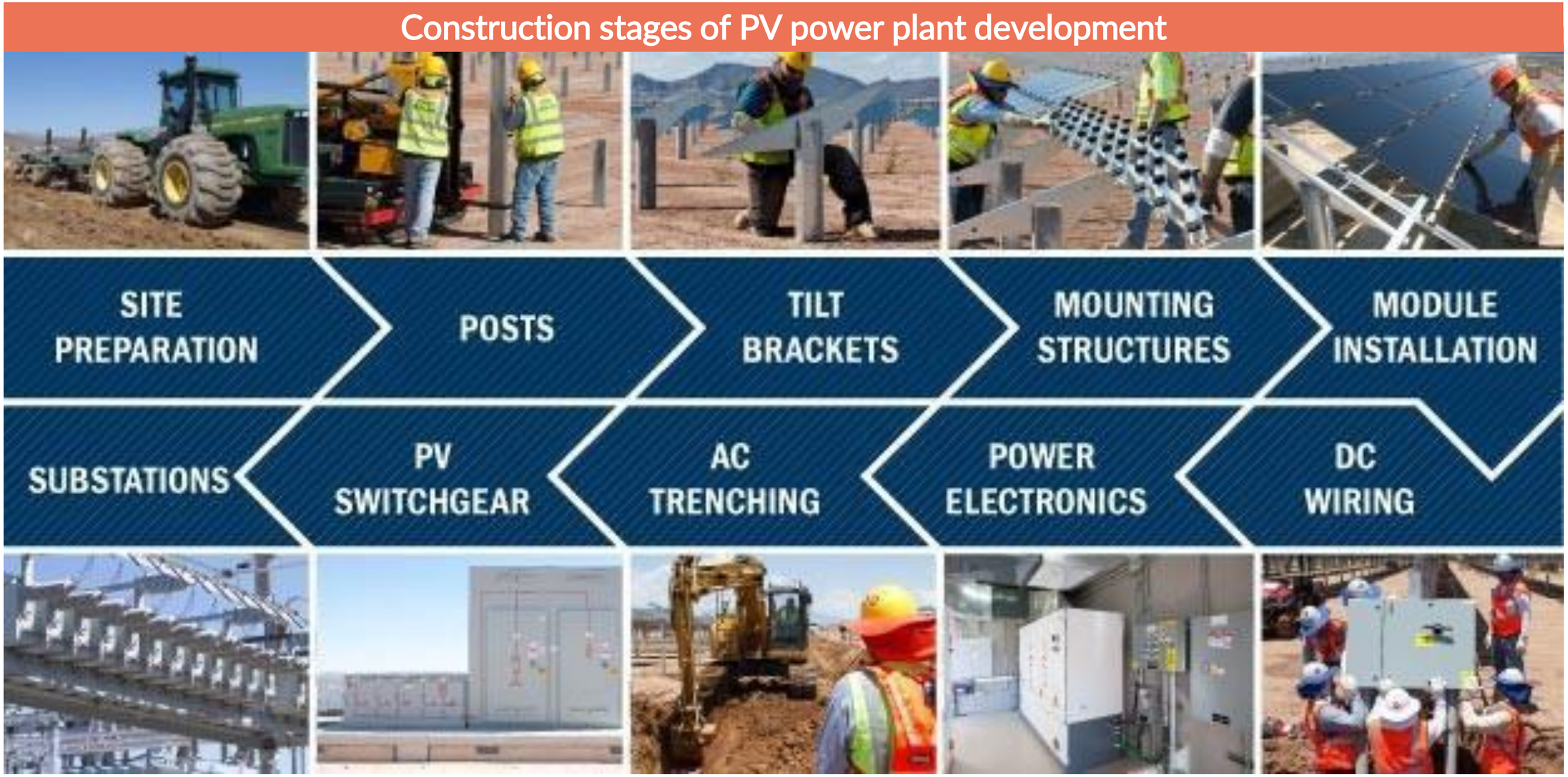
Logistical aspects:

- **Transport**: PV is modular, therefore special transport is not required (standard trucks can be used.) Largest items are transformers, standard housing for inverters, DC cable drums.
- Roads: Since no very large items are being transported, no special preparation of the roads is needed

Inverter housing ; *Source: SMA*

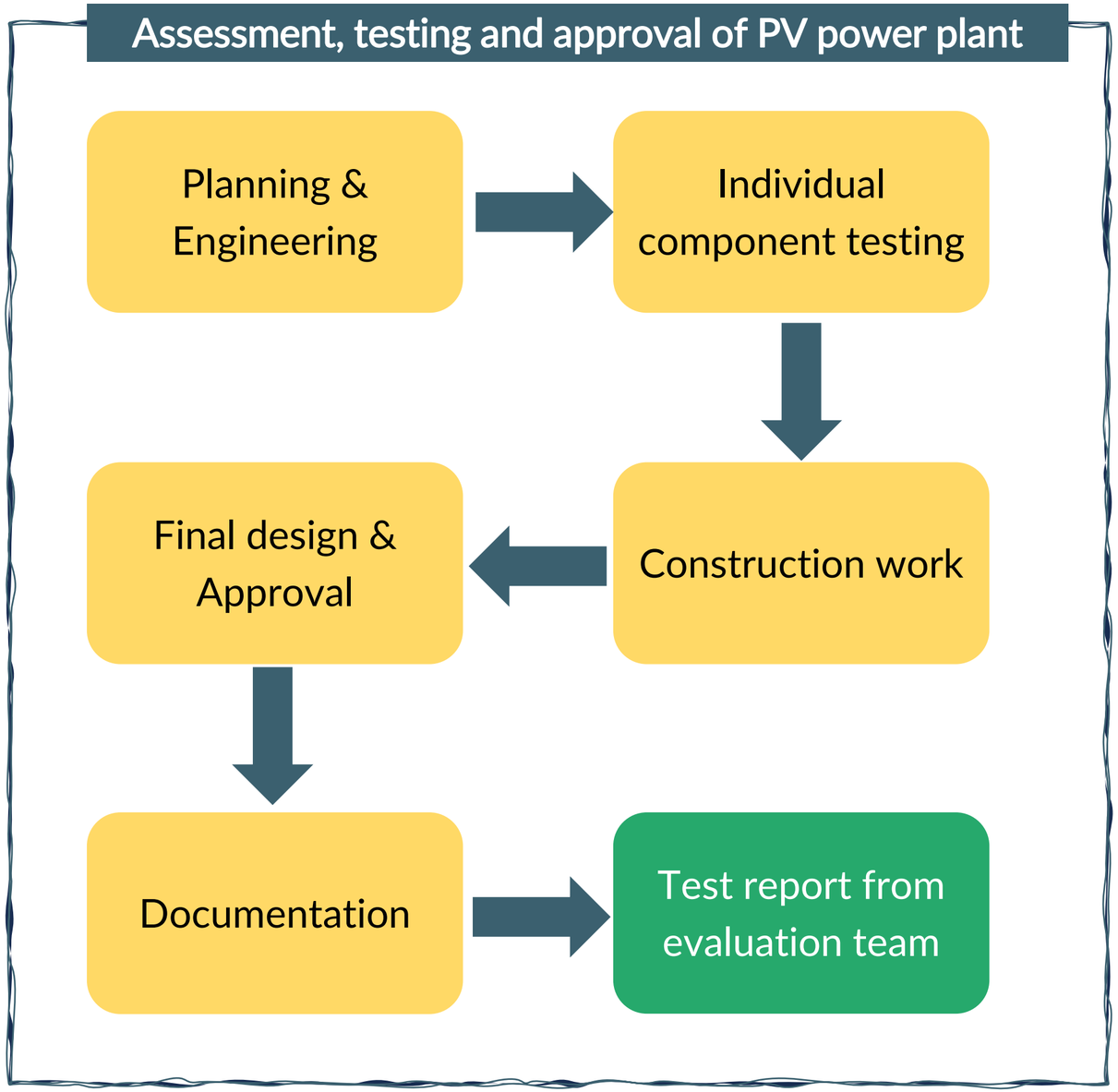
Wooden cable drum

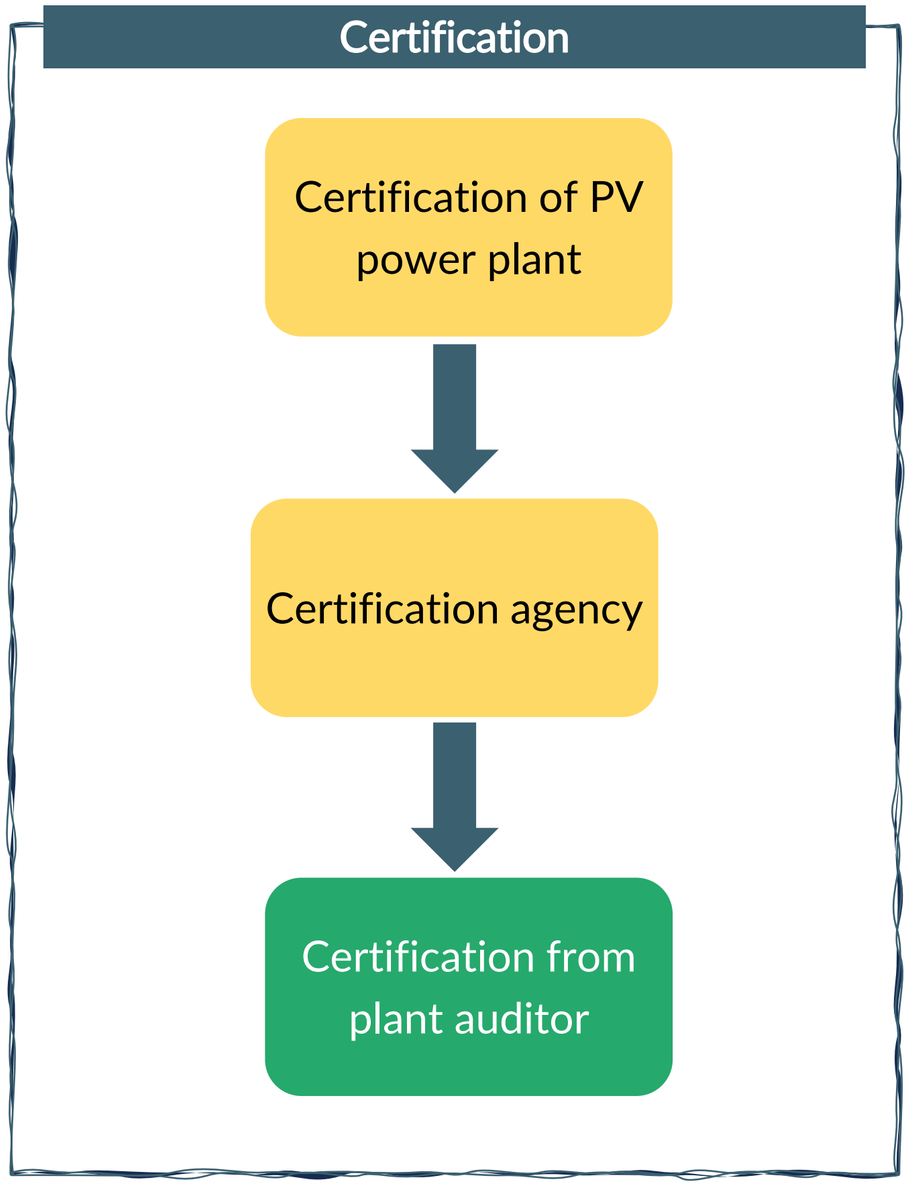
PV POWER PLANT CONSTRUCTION



Source: https://www.linkedin.com/pulse/your-complete-guide-pv-plant-construction-eslam-allam

TESTING & CERTIFICATION





OPERATIONS & MAINTENANCE

The operation and maintenance of solar PV systems generally involves the following components:

- General safety
- Safety instructions
- Maintenance
- SPV technology & components
- Preventive maintenance
- Trouble shooting for PV systems

OPERATIONS & MAINTENANCE

OPERATION AND MAINTENANCE GUIDELINES

RESPONSIBILITY FOR EQUIPMENT FAILURE

- **Negligence clause:** Negligence or maloperation responsibility lies with the Bidder.
- **Repair/replacement:** Bidder undertakes free repair or replacement if equipment failure is due to negligence/maloperation by their operator.

CLEANING ROUTINE

- **Frequency:** Clean solar modules every fortnight or as per site conditions.
- **Responsibility:** Beneficiary to perform the task.
- **Vendor role:** Vendors educate beneficiaries on the importance and proper cleaning techniques.

EQUIPMENT TESTING AND CALIBRATION

- **Maintenance responsibility:** Bidder maintains testing instruments.
- **Calibration Requirement:** Every 2 years from accredited labs.
- **Documentation:** Calibration certificates kept for reference.

COMPLIANCE FOR ENERGY GENERATION

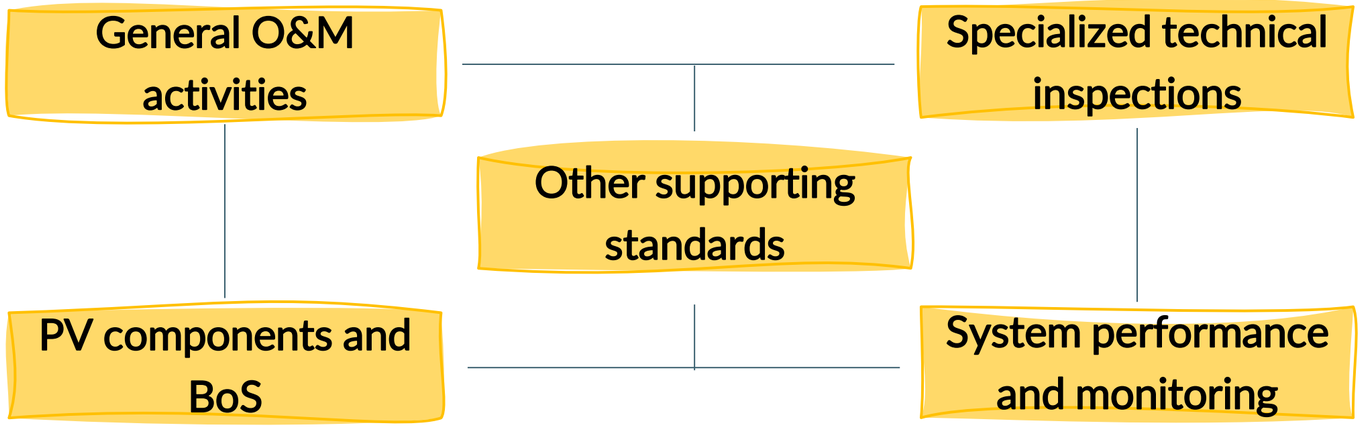
- **O&M Standards:** Compliant with grid requirements.
- **Objective:** Ensure committed energy generation.

ROUTINE CHECKS AND MAINTENANCE

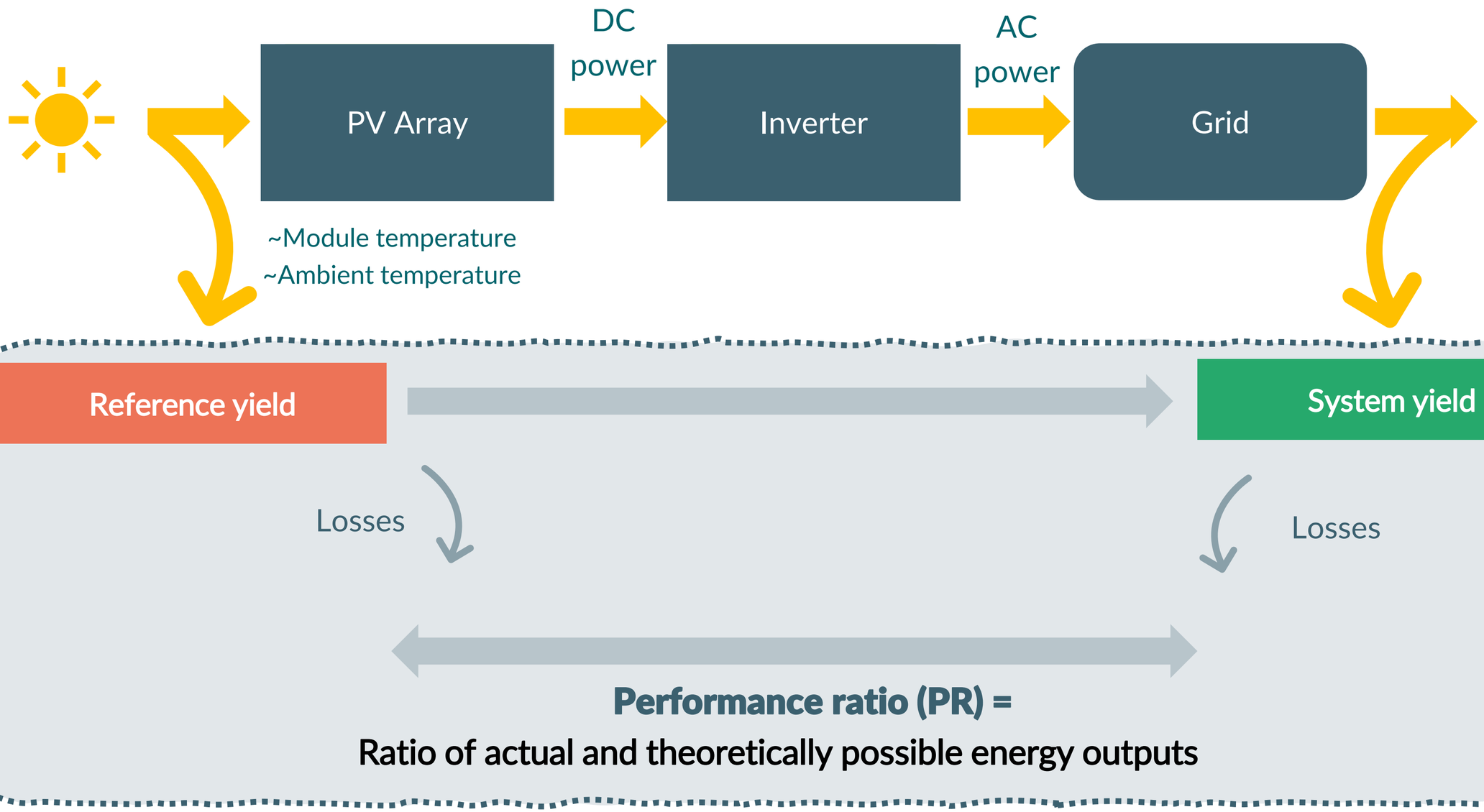
- **Periodic inspections:** Modules, PCUs, and BoS.
- **Prompt action:** Immediate replacement of defective equipment.
- **Supply management:** All necessary spares and consumables supplied as per recommendations.

STANDARDS APPLICABLE IN OPERATION & MAINTENANCE

General O&M activities	Specialized technical inspections	PV components and BoS	System performance and monitoring	Other supporting standards
• EN 13306 • IEC 62446 - 1: 2016 • IEC 62446 - 2 • IEC 63049: 2017 • IEC 60364 - 7 - 712: 2017 • IEC 62548	• IEC TS 62446 - 3: 2017 • IEC 61829: 2015 • IEC TS 60904 - 13: 2018	• EN 50380 • IEC 61215 (all parts) • IEC 61439 • IEC 61557 (all parts) • IEC 61730 (all parts) • IEC 62093 • IEC 62109 (all parts) • IEC TS 62804 (all parts) • IEC TS 62915 • IEC TS 63126	• IEC 61724 - 1: 2017 • IEC 61724 - 2: 2016 • IEC 61724 - 3: 2016 • IEC 61724 - 4 • IEC 63019: 2019 • ISO 6847: 1992	• IEC TS 61836 • IEC TS 62738: 2018 • IEC TR 63149: 2018 • IEC TS 62548 • IEC 60891: 2009 • IEC 61853 - 1: 2011 • IEC 61853 - 2: 2016 • IEC 61853 - 3: 2018 • IEC 61853 - 4: 2018 • IEC 60904 - 5: 2011 • IEC 60904 - 4



MONITORING & EVALUATION



Derived from source: , Awaz Rashid & Gulala Safari . 2021. Technical performance evaluation of solar photovoltaic systems. A case study of eight PV systems on the swedish market installed at RISE research facilities

FACTORS TO MONITOR

Production quality: cell process, materials, etc.

- Dirt/soiling
- Location/surrounding
- Seasonal behavior: snow, rain, temperature, etc.
- Shadows
- Etc.

Energy yield

1) Reference
2) System

- Long term behavior of system components: PV module, inverter
- Radiation measurement: Sensor quality
- Different spectrum: Direct/diffuse irradiation
- Low light behavior
- Measurement uncertainty
- Temperature behavior

- Maximum power point tracking of inverter
- Efficiency of inverter
- Design of overall PV power plant

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END OF CHAPTER 3 OF 3

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