







Task 14 Solar PV in the 100% RES Power System

Communication and Control for High PV Penetration under

Smart Grid Environment

Case Study Analysis

2021

PVPS

**Report IEA-PVPS TX-XX:2021**

1. SCENARIO DEFINITiON AND QUESTIONnAIRe OF <COUNTRY XY or organization XY>

## Role of Editor

Name of editor/ organization (optional):

|  |
| --- |
|  |

E-mail (optional):

|  |
| --- |
|  |

Role of editor:

Grid operator

Grid regulator

Metering point operator

PV-system operator

PV-system owner

Energy market retailer

Energy service provider

Scientific organization

Standardization committee

Technical / legal commission

PV-system manufacturer

IT service provider

Other, please specify

|  |
| --- |
|  |

## Scenario description

Scenario description:

Please specify the scenario here.

|  |
| --- |
|  |

# Scenario: Country/Organization <XY>

## Regulatory Documents

Which legal requirements are relevant for the operators of grid-connected PV systems in your country?

|  |
| --- |
|  |

Which business models do PV systems have in the scope of your scenario?

Feed-in tariff (FIT)

Self-consumption

Net metering

Virtual power plant (e.g. participation with an aggregator)

Participation in energy market

Power purchase agreement (PPA)

Peer-to-peer contract

Other, please specify:

|  |
| --- |
|  |

## Grid Connection

To which voltage levels are the PV systems connected in your scenario?

LV (low voltage)

MV (medium voltage)

HV (high voltage)

More than one is possible

Which connection topologies are allowed?

Single Phase

Multiple Single Phase

3 Phase

Split Phase

Not defined

Which further specialties are regulated in your project / country concerning grid connection?

|  |
| --- |
|  |

## Metering Data for Invoicing

Which Parameters are recorded?

Mandatory Optional

Active energy

Reactive energy

Other, please specify:

|  |
| --- |
|  |

Which interval is used for the measurement and data transmission (for invoicing)?

Measurement Data transmission

Annually

Quarterly

Monthly

Weekly

Daily

Hourly

Quarter hourly

Minutes

Other, please specify

|  |
| --- |
|  |

How are these data collected?

Collected by DSO-Official

Meter operator

Costumer sends Postcard

Costumer uses an App / Webpage form

Transmitted (Smart Meter)

Is it planned to transmit the measurements in the future?

Yes, please specify

|  |
| --- |
|  |

No

If measurements are transmitted or will be transmitted in the future, please give details on technology and procedures.

|  |
| --- |
|  |

## Metering Data for grid operation

Which Parameters are recorded?

Mandatory Optional

Active energy

Reactive energy

Active power

Reactive power

Phase active power

Phase voltage

Phase currents

Grid frequency

THD or harmonics

Which interval is used for the measurement and data transmission (for grid operation)?

Measurement Data transmission

Annually

Quarterly

Monthly

Weekly

Daily

Hourly

Quarter hourly

Minutes

Other, please specify

|  |
| --- |
|  |

How are these data collected?

Collected by (DSO) Official

Meter operator

Costumer uses an App / Webpage form

Transmitted (Smart Meter)

Is it planned to transmit the measurements in the future?

Yes, please specify

|  |
| --- |
|  |

No

If measurements are transmitted or will be transmitted in the future, please give details on technology and procedures.

|  |
| --- |
|  |

## PV System Registration

Which registrations are required for the grid interconnection of a PV system?

Registration at grid operator (asset management)

Registration at grid operator (grid operation)

Registration at renewable energy system register

Registration at energy market register

Valid certificate for PV system operation

Other, please specify

|  |
| --- |
|  |

## Ancillary Services

Which preconditions are required for the grid-connected operation of a PV inverter? [6] [12]

FRT (Fault Ride Through) capability

Automatic power limitation/disconnection in over frequency cases

Voltage rise check by DSO before installation

Communication access (e.g. for curtailment)

Other, please specify

|  |
| --- |
|  |

Which ancillary services are provided for grid operators by grid-connected PV inverters? [12] [13]

Frequency regulation & reserve power

Harmonic compensation

Fast ramping resources

Grid dynamic voltage support

Grid restart after blackout

Grid-disconnected microgrid operation (Unintentional islanding)

Reactive power capability & voltage regulation

Other, please specify

|  |
| --- |
|  |

Is there a compensation for delivering ancillary services?

No

Yes, please specify

|  |
| --- |
|  |

## Monitoring & Remote Control

Is there any regulatory document for PV monitoring?

No

Yes, please specify

|  |
| --- |
|  |

Which control methods are applied to PV systems?

Active power curtailment (set a feed-in limit)

Special commands for ancillary services (e.g. reactive power provision)

Modification of inverter parameters (e.g. set power factor of the inverter)

Forecast-based scheduling

Local regulation regarding customer home energy system

Other, please specify

|  |
| --- |
|  |

Which protocols and technologies are considered in the control commands? [15] [16] [17]

Control based on relays

IEC 60870-5-103/104 (classic standard for tele control) [18]

IEC 61850 (modern standard for tele control) [19]

IEC 61970, IEC 61968 (CIM: Common Information Model) [20] [21]

Open ADR [22]

IEEE 2030.5 [23]

SunSpec Modbus-TCP [24]

Proprietary protocols, please specify

|  |
| --- |
|  |

Which communication infrastructure is used to send the commands?

Ripple control (long wave radio)

DSL

Power line communication

Fiber optics

GSM /UMTS/LTE

5G

Fax or Papers exchange or telephone

Other, please specify

|  |
| --- |
|  |

## Opportunities for PV integration into smart grids

Which of the following scenarios are currently regarded in your country? In addition, which will be considered in the future? [26] [27]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. | Scenarios for the integration of PV in the smart grid | Present | Planned | Future | Not Discussed |
| 1 | Transmit measurements  Transmission of meter data for invoicing and gird measurements for grid operation |  |  |  |  |
| 2 | Control of active power  Direct control of PV system feed-in active power, e.g. via active power curtailment |  |  |  |  |
| 3 | Control of reactive power  Using the grid-support functionalities of PV inverters for reactive power regulation (e.g. voltage support) |  |  |  |  |
| 4 | Use of existing ICT infrastructure  Realizing tele-communication without installing extra ICT devices (e.g. ICT device in customer network) |  |  |  |  |
| 5 | Change parameters for the inverter control  Amendment of inverter operation modes by configuring inverter control parameters (e.g. P(f), V-control modes) |  |  |  |  |
| 6 | Inverter Plug and Play  Automatic registration in the MDS (metering data system) and SCADA of grid operator |  |  |  |  |
| 7 | Autonomous DER functions  Autonomous control of DER on behalf of (coordinated and cascaded) DSO/TSO commands or market signal |  |  |  |  |
| 8 | Provide black start capabilities  Contributing to grid restart after local or regional grid black out |  |  |  |  |
| 9 | Storage specific function  Supporting operational or economic use cases with different types of energy storage for customers and grid operators |  |  |  |  |
| 10 | Time-based scheduling  Day-ahead time-based scheduling of PV control configuration regarding available weather/load forecast |  |  |  |  |
| No. | Scenarios for the integration of PV in the smart grid | Present | Planned | Future | Not Discussed |
| 11 | Monitor PV-Status and provide emergency alarm  Monitoring of PV system operation states and alert the stakeholder/operator in case of emergency and operational fault |  |  |  |  |
| 12 | Participation in local energy markets  Enabling energy trade of PV feed-in surplus in local energy market |  |  |  |  |
| 13 | Neighborhood energy exchange (within one feeder)  Enabling energy trade of PV feed-in surplus with consumers in neighborhood |  |  |  |  |
| 14 | Participation in flexibility-platform  Participating in flexibility trade by providing PV system capacity as reserve power (e.g. via prosumer aggregation) |  |  |  |  |
| 15 | Participation in crossing region energy markets  Enabling energy trade of PV feed-in surplus in crossing region energy market (e.g. via p2p energy trade, block-chain application) |  |  |  |  |
| 16 | Documentation of executed PV curtailments  Providing evidence for compensation of flexibility trade by documentation executed power curtailments and other kinds of power regulation restrictions |  |  |  |  |
| 17 | PV - EV compensation  Enabling compensation of EV peaks by charging with PV surplus, hybrid storage system could also be associated |  |  |  |  |
| 18 |  |  |  |  |  |
| 19 |  |  |  |  |  |
| 20 |  |  |  |  |  |

## Security

Which of the 4 Goals of an IT system security policy / discussion is rated the most? Please give numbers to rate the 4 different goals from 0 = not considered / not important to 10 = most important [28]

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Goals | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | Confidentiality (also considers privacy issues) |  |  |  |  |  |  |  |  |  |  |  |
| 2 | Integrity |  |  |  |  |  |  |  |  |  |  |  |
| 3 | Availability |  |  |  |  |  |  |  |  |  |  |  |
| 4 | Accountability |  |  |  |  |  |  |  |  |  |  |  |

Which measures for IT security should be considered? [9] [28] [29] [30] [31]

|  |  |  |  |
| --- | --- | --- | --- |
| No. | IT security measure | Present | Future |
| 1 | Threat analysis & risk management for PV systems to identify threats and vulnerabilities |  |  |
| 2 | Regular cyber security assessment for existing infrastructure |  |  |
| 3 | User authentication |  |  |
| 4 | Device identification and authentication |  |  |
| 5 | Role-based device access control |  |  |
| 6 | Attack/intrusion detection system |  |  |
| 7 | ICT cryptographic techniques |  |  |
| 8 | Internet cryptography |  |  |
| 9 | Wireless cryptography |  |  |
| 10 | Certificate-based PKI cryptography and key management |  |  |
| 11 | Design secure network configurations |  |  |
| 12 | Implementation of security testing and validation procedures |  |  |
| 13 | Redundant communication network |  |  |
| 14 | Redundant equipment |  |  |
| 15 | Centralized monitoring and control via SCADA system |  |  |
| 16 | Centralized power system analysis and control for DER via EMS and DMS |  |  |
| 17 | Security awareness & training for system operator staffs |  |  |
| 18 | Utilization of block-chain technologies |  |  |
| 19 | Secured storage and transport of ICT devices |  |  |
| 20 |  |  |  |

Please rate the following scenarios for IT security in respect to utilization vs danger (risk vs opportunity) with following rating:

* -2: This is a great danger
* -1: we consider the use but have doubts
* ND: Not discussed
* +1: it is interesting and offers potential
* +2: This is the way to go

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Scenarios for the integration of PV in the smart grid** | **-2** | **-1** | **ND** | **+1** | **+2** |
| 1 | Transmit measurements |  |  |  |  |  |
| 2 | Control of active power |  |  |  |  |  |
| 3 | Control of reactive power |  |  |  |  |  |
| 4 | Use of existing ICT infrastructure |  |  |  |  |  |
| 5 | Change parameters for inverter control |  |  |  |  |  |
| 6 | Inverter Plug and Play |  |  |  |  |  |
| 7 | Autonomous DER functions |  |  |  |  |  |
| 8 | Provide black start capabilities |  |  |  |  |  |
| 9 | Storage specific function |  |  |  |  |  |
| 10 | Time-based scheduling |  |  |  |  |  |
| 11 | Monitor PV Status and provide emergency alarm |  |  |  |  |  |
| 12 | Participation in local energy markets |  |  |  |  |  |
| 13 | Neighborhood energy exchange (within one feeder) |  |  |  |  |  |
| 14 | Participation in flexibility-platform |  |  |  |  |  |
| 15 | Participation in crossing region energy markets |  |  |  |  |  |
| 16 | Documentation of executed PV curtailments |  |  |  |  |  |
| 17 | PV - EV compensation |  |  |  |  |  |
| 18 |  |  |  |  |  |  |
| 19 |  |  |  |  |  |  |
| 20 |  |  |  |  |  |  |

List of abbreviations

|  |  |
| --- | --- |
| ADR | Automated Demand Response |
| CIM | Common Information Model |
| CLS | Controllable Local System |
| DER | Distributed Energy Resources |
| DSL | Digital Subscriber Line |
| DSO | Distribution System Operator |
| EEG | Erneuerbare-Energien-Gesetz (English: German Renewable Energies Act) |
| EMS | Energy Management System |
| EnWG | Energiewirtschaftsgesetz (English: German Energy Industry Act) |
| EV | Electric Vehicle |
| FIT | Feed in Tariff |
| FRT | Fault Ride Through |
| GDEW | Gesetz zur Digitalisierung der Energiewende (English: Law on the Digitization of the Energy Transition) |
| GSM | Global System for Mobile Communications |
| HAN | Home Area Network |
| HV | High Voltage |
| ICT | Information and Communication Technologies |
| IEA | International Energy Agency |
| IEC | International Electrotechnical Commission |
| LMN | Local Metrological Network |
| LTE | Long Term Evolution |
| LV | Low Voltage |
| MDS | Metering Data System |
| MV | Medium Voltage |
| NABEG | Netzausbaubeschleunigungsgesetz Übertragungsnetz (English: Grid Expansion Acceleration Act) |
| PKI | Public Key Infrastructure |
| PPA | Power Purchase Agreement |
| P2P | Peer to Peer  Peer-to-PeerPeer  Peer-to-Peer |
| PV | Photovoltaic |
| SCADA | Supervisory Control and Data Acquisition |
| SMGW | Smart Meter Gateway |
| TSO | Transmission System Operator |
| THD | Total Harmonic Distortion |
| UMTS | Universal Mobile Telecommunications System |
| VDE | Verband der Elektrotechnik, Elektronik und Informationstechnik (English: Association for Electrical, Electronic and Information Technologies) |
| WAN | Wide Area Network |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

References

|  |  |
| --- | --- |
| [1] | "EEG - Gesetz für den Ausbau erneuerbarer Energien," Germany, 2017. |
| [2] | BDEW, "Stellungnahme zur Konsultation zum Festlegungsver-fahren zur Informationsbereitstellung für Redispatch-Maßnahmen," Berlin, 2020. |
| [3] | BDEW, "BDEW-BranchenlösungRedispatch2.0," Berlin, 2020. |
| [4] | BMWi, "Gesetz zur Änderung des Erneuerbare-Energien-Gesetzes und weiterer energierechtlicher Vorschriften," Berlin, 2020. |
| [5] | "EnW - Gesetz über die Elektrizitäts- und Gasversorgung," 2005. |
| [6] | VDE, "Power Generating Plants in the Low Voltage Grid (VDE-AR-N 4105)," VDE, Berlin, 2019. |
| [7] | BMWi, "Gesetzzur Digitalisierung der Energiewende," Bonn, 2016. |
| [8] | "NABEG - Netzausbaubeschleunigungsgesetz Übertragungsnetz," Germany, 2011. |
| [9] | BSI, "TR-03109-1 Anforderungen an die Interoperabilität der Kommunikationseinheit eines intelligenten Messsystems," Bonn, 2019. |
| [10] | VDE, "Lastenheft Smart-Meter-Gateway - Funktionale Merkmale," VDE, Berlin, 2019. |
| [11] | Netztransparenz.de, "EEG-Anlagenstammdaten( eng. Renewable Energy System master data), online: https://www.netztransparenz.de/EEG/Anlagenstammdaten". |
| [12] | IEEE, "Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces," IEEE, New York, 2018. |
| [13] | IRENA, "Innovation landscape brief: Innovative ancillary services," Abu Dhabi, 2019. |
| [14] | BNetzA, "EEG-Re­gis­ter­da­ten und -För­der­sät­ze," Bonn, 2020. |
| [15] | IEC, "IEC Smart Grid Standardization Roadmap," IEC, 2010. |
| [16] | M. Kuzlu et al., "A comprehensive review of smart grid related standards and protocols," in *2017 5th International Istanbul Smart Grid and Cities Congress and Fair (ICSG)*, Istanbul, 2017. |
| [17] | I. Onunkwo, "Forthcoming report: Recommendations for Data-in-Transit Requirements for Securing DER Communications, No. SAND2020-12704. Sandia National Lab. (SNL-NM)," Albuquerque, 2020. |
| [18] | IEC, "IEC 60870-5-103:1997, Telecontrol equipment and systems - Part 5-103: Transmission protocols - Companion standard for the informative interface of protection equipment," IEC, Geneva, 1997. |
| [19] | IEC, "IEC 61850 Series: Communication networks and systems for power utility automation," 2020. |
| [20] | IEC, "IEC 61970 Series - Energy management system application program interface (EMS-API)," 2020. |
| [21] | IEC, "IEC 61968-11: Application integration at electric utilities - System interfaces for distribution management - Part 11: Common information model (CIM) extensions for distributio," IEC, 2013. |
| [22] | O. Alliance, "OpenADR 2.0 Profile Specification," 2012. |
| [23] | IEEE, "Standard for Smart Energy Profile Application Protocol," 2018. |
| [24] | S. Alliance, "SunSpec Modbus Technology Overview, Model Reference & Model Specification," 2020. |
| [25] | EEBUS Initiative e.V. , "EEBUS UC Technical Specification," Cologne, 2019. |
| [26] | BMWi, "German national research project SINTEG-C/sells, https://csells.net/en/about-c-sells/work-packages.html," Germany. |
| [27] | S. Allem et al., "A Review of Strategies to Increase PV PenetrationLevel in Smart Grids," *Energies,* p. 636, 13 2020. |
| [28] | BSI, "BSI-Standard 200-1: Information Security Management Systems (ISMS)," BSI, Bonn, 2017. |
| [29] | IEC/ISO, "ISO/IEC27019 - Information security controls for the energy utility industry / Informationssicherheitsmaßnahmen für die Energieversorgung," 2013. |
| [30] | J. Johnson, "Sandia Report - Recommendations for Distributed Energy Resource Access Control (forthcoming)," 2020. |
| [31] | NIST, "GuidelinesforSmart Grid Cybersecurity," 2014. |
| [32] | VDE, "Technical Connection Rules for Medium-Voltage (VDE-AR-N 4110)," VDE, 2018. |
| [33] | BNetzA, "Marktstammdatenregister (MaStR, eng. Market Master Data Register), online: http://https://www.marktstammdatenregister.de," 2019. |
| [34] | "Systemstabilitätsverordnung - SysStabV (eng. Ordinance to ensure the technical security and system stability of the electricity supply network)," 2012. |
| [35] | VDE, "Technical Connection Rules for High-Voltage (VDE-AR-N 4120)," VDE, 2018. |