





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):

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E-mail (optional):

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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

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## Scenario description

Scenario description:

Please specify the scenario here.

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# Scenario: Country/Organization <XY>

## Regulatory Documents

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

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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:

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## 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?

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## Metering Data for Invoicing

Which Parameters are recorded?

Mandatory Optional

Active energy [ ]  [ ]

Reactive energy [ ]  [ ]

[ ]  Other, please specify:

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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

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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

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[ ]  No

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

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## 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

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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

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[ ]  No

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

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## 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

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## 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

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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

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Is there a compensation for delivering ancillary services?

[ ]  No

[ ]  Yes, please specify

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## Monitoring & Remote Control

Is there any regulatory document for PV monitoring?

[ ]  No

[ ]  Yes, please specify

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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

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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

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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

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## 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]

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| --- | --- | --- | --- | --- | --- |
| No. | Scenarios for the integration of PV in the smart grid | Present | Planned | Future | Not Discussed |
| 1 | Transmit measurementsTransmission of meter data for invoicing and gird measurements for grid operation | [ ]  | [ ]  | [ ]  | [ ]  |
| 2 | Control of active powerDirect control of PV system feed-in active power, e.g. via active power curtailment | [ ]  | [ ]  | [ ]  | [ ]  |
| 3 | Control of reactive powerUsing the grid-support functionalities of PV inverters for reactive power regulation (e.g. voltage support) | [ ]  | [ ]  | [ ]  | [ ]  |
| 4 | Use of existing ICT infrastructureRealizing tele-communication without installing extra ICT devices (e.g. ICT device in customer network)  | [ ]  | [ ]  | [ ]  | [ ]  |
| 5 | Change parameters for the inverter controlAmendment 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 functionsAutonomous control of DER on behalf of (coordinated and cascaded) DSO/TSO commands or market signal | [ ]  | [ ]  | [ ]  | [ ]  |
| 8 | Provide black start capabilitiesContributing to grid restart after local or regional grid black out | [ ]  | [ ]  | [ ]  | [ ]  |
| 9 | Storage specific functionSupporting operational or economic use cases with different types of energy storage for customers and grid operators | [ ]  | [ ]  | [ ]  | [ ]  |
| 10 | Time-based schedulingDay-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 alarmMonitoring of PV system operation states and alert the stakeholder/operator in case of emergency and operational fault | [ ]  | [ ]  | [ ]  | [ ]  |
| 12 | Participation in local energy marketsEnabling 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-platformParticipating in flexibility trade by providing PV system capacity as reserve power (e.g. via prosumer aggregation) | [ ]  | [ ]  | [ ]  | [ ]  |
| 15 | Participation in crossing region energy marketsEnabling 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 curtailmentsProviding evidence for compensation of flexibility trade by documentation executed power curtailments and other kinds of power regulation restrictions  | [ ]  | [ ]  | [ ]  | [ ]  |
| 17 | PV - EV compensationEnabling 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]

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| 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]

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| 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

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| **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 PeerPeer-to-PeerPeerPeer-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 |
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