Test Case 20

Author OFFIS   Version 1.0
Project ERIGrid 2.0   Date   02/02/2021

Name of the Test Case	Test methods for integration/interoperability assessment for building and resource-level management systems in participation with aggregation platform
Narrative	With the increasing reliance of MV and LV level power systems on DERs, it becomes important to ensure a wide interoperability between different aggregation infrastructures and local management systems of DERs, including EVs, energy storages, PV, wind turbines, and smart buildings. Indicators for the achieved interoperability are the ease of transfer of a DER from one Virtual Power Plant (VPP) to another, the coordinated control and monitoring of the resources, and the potential for service matching among the providers. These processes depend on a functional information exchange between a central control and the DER control systems. This test case applies to aggregator platforms as well as peer-to-peer (P2P) trading platforms for energy community management. Two scales of the power system are within the scope of testing: MV/LV distribution networks and LV distribution feeders, each with the potential for various loads, renewable generation and demand side flexibility.
Function(s) under Investigation (*FuI*) "the referenced specification of a function realized (operationalized) by the object under investigation"	• DER integration into a new platform • Communication for aggregation, service matching, failover, configuration and/or flexibility trade • Ancillary service provision under different scales of aggregation and control solutions
Object under Investigation (*OuI*) "the component(s) (1..n) that are to be qualified by the test"	• Aggregator platforms / P2P trading platforms • Local management systems of buildings/resources • Aggregation infrastructure of power systems
Domain under Investigation (*DuI*): "the relevant domains or sub-domains of test parameters and connectivity."	• Electrical power system • Control/ICT • Domain of final energy use
Purpose of Investigation *(PoI)* The test purpose in terms of Characterization, Verification, or Validation	• *PoI#1:* Evaluate aggregator platforms / P2P trading platforms for capability of seamless integration of new DER participants • *PoI#2:* Evaluate local management systems of buildings/resources in terms of interoperability with platforms • *PoI#3:* Study the transfer process of DERs from one aggregation infrastructure to another • *PoI#4:* Validate operational capability of flexibility services directly after configuration of introduced DER

System under Test (*SuT*): Systems, subsystems, components included in the test case or test setup.	• Aggregation infrastructures and platforms: energy sharing coordinators (control systems), communication systems, measuring and monitoring devices • Local energy communities (LECs): DERs (e.g., PV, wind turbines, energy storage systems, smart buildings), flexible loads (domestic), inflexible loads (e.g., ships) • Local management systems of buildings/resources and reactive power controllable equipment • Distribution system (lines, transformers, etc.): power distribution network (MV/LV) / LV distribution feeder
Functions under Test (*FuT*) Functions relevant to the operation of the system under test, including FuI and relevant interactions btw. OuI and SuT.	**In-focus functions**: Controlling functions of the systems (i.e., aggregator network management control methods, DER controlling, storage system controlling), DER configuration and integration **Emulated functions**: Aggregator platform services **Actuation functions**: Controllable loads, demand response signals **Observer functions**: Monitoring of network properties (e.g., voltage, current, uncontrollable load)
Test criteria *(TCR)* Formulation of criteria for each PoI based on properties of SuT; encompasses properties of test signals and output measures.	• Seamless integration and configuration process • Applicability of DERs to various diverging aggregation infrastructures • Effective matching of available services and optimal dispatch • Scalability and flexibility of aggregation and control solutions • Functional communication for aggregator service provision
Target Metrics *(TM)* Measures required to quantify each identified test criteria	• Workload, time and cost of integration and configuration process • Software and operation adjustments required for control of additional DERs • Addition and improvement of aggregator services (in terms of fulfillment time, reliability, energy efficiency etc.)
Variability Attributes *(VA)* controllable or uncontrollable factors and the required variability; ref. to PoI.	• Properties of connected networks (e.g., medium voltage, frequency, load) • Participating DERs (number & type) • Concurrent services (interference/synergy) • Platform specific requirements (e.g., coordination with traditional voltage support components for voltage regulation)
Quality Attributes *(QA)* threshold levels for test result quality	• Stable grid operation and integrity (respecting power quality standard EN50160)

as well as pass/fail criteria.	• Interoperability of DER management system to at least two different platforms • Short integration process

Qualification Strategy

Test Specifications to this Test Case will address the PoI for a specific DER type. TS 20.1 covers PoI#2 and PoI#4 for PV systems directly within its testing scope, while providing the means to evaluate PoI#1 and PoI#3 based on the results accomplished by the previously integrated PV system.

Test Specification 20.1

Reference to Test Case	TC20: Test methods for integration/interoperability assessment for building and resource-level management systems in participation with aggregation platform
Title of Test	**Precise control of PV system operational settings (smart inverter) for reactive power and active power limitation on different aggregation platforms**
Test Rationale	In this Test Scenario, a PV plant is tested for interoperability with two distinct aggregation infrastructures. The plant may start out in one of the networks and therefore already be known as interoperable to the initial platform prior to transfer. Otherwise, the interoperability has to be proven for both infrastructures independently. The PV plant is governed by a programmable automation control system that is scalable and fully integrated with all required data acquisition, analytical and control logic functionalities to demonstrate advanced and reliable PV system operations. The system is equipped with smart inverters and should be capable of failure diagnosis, communication with the aggregation platform (Modbus TCP), as well as storage and ancillary services compliant to the grid code. The two networks should differ in their share of Renewable Energy Sources (RES) and medium voltages in order to validate the systems' extensive interoperability.
Specific Test System	The test system consists of the PV system and the separate (simulated) aggregation infrastructures to be qualified for interoperability. Additional generators and reactive power controllable equipment at different voltage levels are connected to each network. The test is either conducted with geographically distributed HIL or within a simulation.
Target measures	Which values are monitored and which timeframes are acceptable depend on the system functionality under assessment. During congestion management, the PV operation should respect a reserves availability of at least 20%, as well as the direct voltage operating regions of the grid. If not linked to specific grid restrictions, there should be no significant performance variance for connection to the two distinct networks. All status reports and schedules must be communicated accurately and timely between the control systems.
Input and output parameters	Uncontrollable input parameters: • Grid topology • Generation and load profiles of other grid participants Controllable input parameters: • PV system controllers parameters • Voltage set-point • Frequency set-point

	• Load value
	Output parameters: • Communication acknowledgements • Node voltages • Power losses
Test Design	Testing the functionalities in their operation constitutes a practical assessment for the interoperability of the PV control system with each aggregation platform. The PV system has to fulfill ancillary services and reporting duties towards the aggregation management. It has to process and implement received activation plans. The evaluation of the system response can be done within a specific flexibility redistribution scenario. To this end, a congestion will be simulated for the connected power system. The information exchanged between the control systems during the reallocation process will be protocolled on dedicated communication channels.
Initial system state	The PV system is connected to one of the networks. The communication channels to the associated aggregation platform are set up. The initial power flow conditions are: • The voltage/frequency value (output) matches the voltage/frequency set-point. • The consumption of the loads should be at least 20% of the maximum consumption. • The combination of the RES units should provide at least 20% of their nominal power.
Evolution of system state and test signals	At first, the power system is sufficiently balanced, the voltage and frequency are nominal, and the PV system reserves are unengaged. Then a congestion emerges, to which the aggregation platform responds by requesting the activation of the PV reserves, alongside those of some additional RES of the network. For testing purposes, these other resources' contribution to the congestion management is marginalized. The PV system control regulates the plant's production and storage release to meet the grid's demands. It incorporates subsequent updates by the platform on these demands to take further disturbances and the activity of the other RES into account, and reports on its current status and energy supply. The exchange concludes with the platform's acknowledgement that the congestion was successfully mitigated by the increased production rate. Network properties such as voltage, frequency and load at relevant sections are monitored during the entire process to verify grid integrity at all times. Further exchanges not covered by the functionalities involved in congestion management can be tested separately and directly (e.g., scheduling or failure reporting).
Other parameters	N/A
Temporal resolution	The simulated part of the test proceeds continuously, with time step sizes depending on the software experiment: • Time constants inside SuT in-between 50 μs and 5 s • Monitoring quantities with a maximum sampling time of 0.1 sec.
Source of uncertainty	• Grid parameters variability (i.e., resistance/inductance ratio) • Timing deviations, communication delays by other participants • Consumers' demand • Environmental conditions
Suspension criteria / Stopping criteria	• Successful congestion mitigation and conclusion of all test runs for PV system functionalities • Each functionality has a predetermined timeframe to operate successfully

	• Violation of grid integrity