Test Case 7

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Name of the Test Case	Evaluation of cost-effective operation of P2P-based local energy system
Narrative Incl. use case and test objectives.	The main advantage of a peer to peer (P2P) based energy system roots on a collective minimization of the costs for energy while maximizing the individual benefits of the prosumers. This way, the benefits for the prosumers are attractive, thus favouring the deployment of distributed energy resources (DERs) and the willingness of the end-users to participate in the local energy market. The operators are responsible for providing the local market platform and take care of their possible congestions while the prosumers have the full control over their DERs. This means a different perspective over the energy management problem, traditionally centred at the distribution system operators who look for certain overall performance and benefits for the full population of DERs (e.g., by providing ancillary services upstream) instead of improving the individual benefits of the participants.
Function(s) under Investigation (*FuI*) "the referenced specification of a function realized (operationalized) by the object under investigation"	• Bidding algorithms of the individual prosumers • Clearing function of the energy trading coordinator
Object under Investigation (*OuI*) "the component(s) (1..n) that are to be qualified by the test"	• Modules for creating the bids at prosumer's level • Module of the energy sharing coordinator for estimating the internal price • Communication modules between a set of converters/distributed energy resources and manageable loads
Domain under Investigation (*DuI*) "the relevant domains or sub-domains of test parameters and connectivity."	• Electrical Power • ICT • Market • Heating/Cooling
Purpose of Investigation *(PoI)* The test purpose in terms of Characterization, Verification, or Validation	• PoI1: Verification of the trading energy platform functioning to get a cost-effective operation for both the energy sharing coordinator and the prosumers (economic criteria) • PoI2: Validation that the control signals derived from the decision-making process are feasible to the controllable electrical devices (technical criteria)

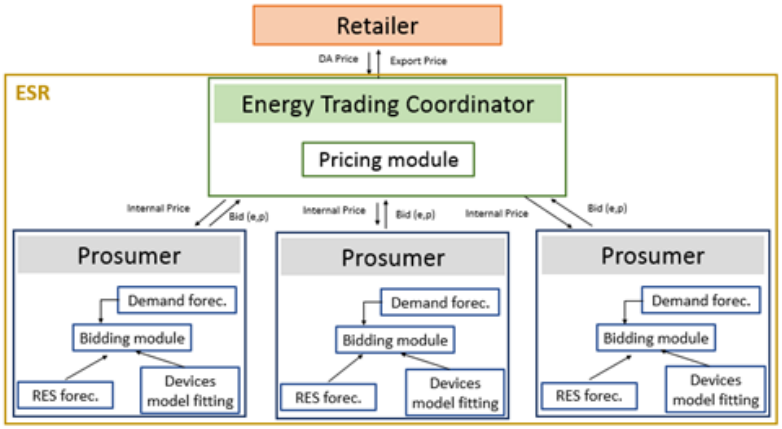
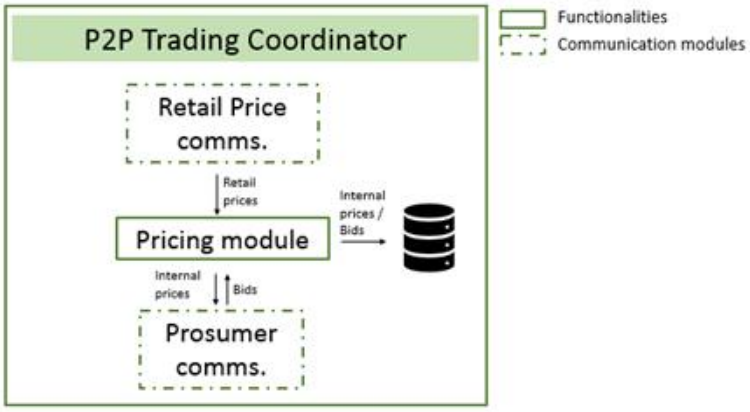
System under Test (*SuT*): Systems, subsystems, components included in the test case or test setup.	Local energy community (LEC), distributed energy resources (DERs), controllers, ICT components (measuring/monitoring devices), benchmark distribution system (optional).
Functions under Test (*FuT*) Functions relevant to the operation of the system under test, including FuI and relevant interactions btw. OuI and SuT.	• Capability of communication among different OuI. • Capability of the device response by real-time to follow different characteristics (output profiles)
Test criteria *(TCR)* Formulation of criteria for each PoI based on properties of SuT; encompasses properties of test signals and output measures.	• The communication module between different agents should guarantee a reliable operating channel to send the bids and internal/external prices. • Each manageable device should adequately adjust its power according to the received signals
Target Metrics *(TM)* Measures required to quantify each identified test criteria	• The execution time of the optimal power/price time-series sent to each device is adequate • Execution time of the P2P platform algorithm • Complying with the network constraints as well as the energy needs of the devices
Variability Attributes *(VA)* controllable or uncontrollable factors and the required variability; ref. to PoI.	• Power set point at a required time (PoI1 & PoI2) • External price variability • Reliability of the forecasted time-series for demand and renewables
Quality Attributes *(QA)* threshold levels for test result quality as well as pass/fail criteria.	• Loss of communication between agents (fail) • Significant deviation from the optimal operating point of the devices respect to the control signal (fail) • Technical operating levels of the grid, i.e., voltage, losses, and thermal capacity (fail)

Qualification Strategy

Two test specifications will be implemented: one for verifying the price algorithm of the trading coordinator along with its communication modules, and another for the verification of the control signals derived from the decision-making process to the controllable electrical devices. Note that the distribution network, mainly at the LV level, can be represented by a benchmark or real grid.

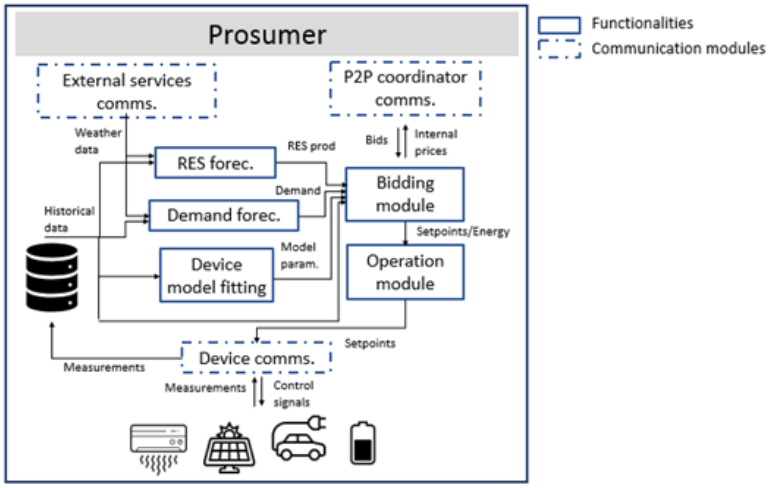
Test Specification TC7.TS01

Reference to Test Case	*TC7*
Title of Test	Validation of the trading coordinator platform to get the internal prices based on the prosumer's received bids.
Test Rationale	As the P2P Trading Coordinator is responsible for receiving the bids from the prosumers and send them back the internal price and is also in charge of managing the trading of energy with the retailer agent, this test seeks to evaluate the algorithm of the pricing module along with the performance of the communication module with the

	latter and the prosumers.
Specific Test System (graphical)	Community-based P2P architecture  P2P Trading Coordinator architecture 
Target measures	• Price signal • Communication signals between agents
Input and output parameters	Input parameters • Retailer's price • Prosumer's bids Output parameters • Internal price
Test Design	Optimise the internal price based on the Prosumer's bids
Initial system state	• Measurement of input parameters • Communication established
Evolution of system state and test signals	Evaluation of the algorithm response up to the calculation of the final internal price
Other parameters	*N/A*
Temporal resolution	It will depend on the price signal sample, which can be from minutes to hour resolution.
Source of uncertainty	Price value, communication delay
Suspension criteria / Stopping criteria	Detection of abnormal price values, communication failure between agents

Test Specification TC7.TS02

Reference to Test Case	*TC7*
Title of Test	Validation that the control signals derived from the decision-making process are feasible to the controllable electrical devices (technical criteria)
Test Rationale	The test is to evaluate the performance of the decision-making

	process in the Bidding module, which outputs are final energy, price bids, and the control signals for the controllable electrical devices.
Specific Test System (graphical)	Prosumer architecture 
Target measures	• Power on the devices and losses on the network • Device status • Voltage signal on several nodes • Price signal
Input and output parameters	Input parameters • Weather data • Historical load data • Grid frequency • Grid voltage • Current per phase • Internal prices • Load parameters Output parameters • Power setpoints per device • Price bids
Test Design	The test considers several consecutive load and generation variations based on the forecasted modules, as wells as price bidding variations. These are needed to adequately evaluate the capability of the operation and bidding modules to cope with these conditions.
Initial system state	• Measurement of input parameters to perform a perfect forecast of RES and demand • Measurement of electrical parameters • The imbalance should be under 5%. • Optimal setpoints to the devices
Evolution of system state and test signals	• Technical constraints (e.g., voltage level, losses, loading, unbalance) are verified as a result of the continuous connection of several controllable electrical devices. • Correction of the prosumers' bids based on their power consumption and generation forecast, as well as the fitting parameters of their devices' models
Other parameters	*N/A*
Temporal resolution	From several minutes to an hour
Source of uncertainty	Environmental conditions, consumers' demand, EVs arrivals, the accuracy of measured signals, communication delay, RES and demand forecasting
Suspension criteria / Stopping criteria	Violation of the technical operating levels of the grid, i.e., voltage, losses, and thermal capacity A significant price deviation due to loss of communication