TITLE: Renewable Energy Community "*Energy City Hall*"	**AUTHORS: CER-ECH, GO-CER** **DATE: 28/11/2021**

Object under Investigation (*OuI*)	**Test Objectives**	**System under Test** (*SuT*)
"The component(s) (1..n) that are to be qualified by the test" The components will be Renewable Energy Communities (REC) as well as Multi Family Residential buildings (MFR). The systems under test for each REC/MFR are multiple. The photovoltaic system, the main player in this research, is studied with regard to producibility, considering the instantaneous power and cumulative energy produced and the charge of the storage, where present. The study of the electricity exchange POD will be of considerable importance, in order to view the electricity entering and leaving the single site. The common electrical system of the building is also considered, to measure the powers involved and the energy consumed for powering the thermal power plant, heat pump and any common services present under the exchange POD. Precisely the heat pump system is tested as regards its operation: this represents the largest share of energy consumed, at least during the winter, so it is necessary to study the thermal production and the characteristics that affect its work (such as environmental conditions and operating point) in order to explain its electrical performance. All the operating information of	*Why is the test needed? What do we expect to find out?* The main objective is to simulate a Smart Grid situation where there are no technical and geographical limitations such as those currently imposed by the Italian regulation, but there is a **large energy community that can exchange electricity between different producers and self-consumers**. In practice, this will simulate the effects of the new rules resulting from the final adoption of RED-II Directive, foreseen by June 2022. The simulation will have to evaluate the effectiveness and performance of such a system and if it can be energetically advantageous when systematically replicated at a wider scale. Having a certified laboratory that can manage such data with high computational capacity and with the right algorithms, will speed up the study and verification process and the results obtained will get some kind of validation, becoming usable at multiple levels. Therefore, a <u>minimum objective</u> required is to collect and store all the significant parameters coming from the different RECs/buildings, which represent a very precious source of data, currently very rare, as there are few RECs/residential buildings that have similar monitoring technologies. The cataloging of these data will serve to make them easily accessible and (through an algorithm that will be studied and improved for this	*Systems, subsystems, components included in the test case or test setup* The subject of the investigation are **RECs** and **MFR** located in the Piedmont Region (Italy). RECs belong to **Magliano Alpi's newtwork** that is being created by clustering different Cities. Magliano Alpi's Network is technically and operationally powered by the Local Operational Team of the CER-ECH called **GO-CER**. Also the nodes and networks of the Renewable Energy Communities (REC) designed and managed by the **Municipality of Magliano Alpi** are going to be included in the investigation activities. The CER "Energy City Hall" (ECH) is coordinating the actions related to ERIGRID. Among the interventions carried out in these works, it's worth quoting a heat pump system is created, electrifying the thermal load of the building, and a photovoltaic system is installed on the roof to provide electric supply. In light of the new Italian regulations, which incorporate and introduce Collective Self-consumption (AUC) and the REC, there is a sizable interest is in the study of the energy flows and the transit within local networks representing the energy communities. The photovoltaic systems of different sites can in fact enable prosumers for other consumers (residential, public or company buildings) located under the same secondary transformer substation, that is today the boundary condition by the Italian law (the

the centralized HVAC systems are also available, such as temperatures and status of the systems, also to be visualized and traceable to explain behaviors and electricity consumption on the meters.

The REC management platforms and BMS system themselves are under test because they carry out the management and interfacing of all of the above, with algorithms implemented internally in order to make the system functional and safe, reporting any anomalies, but also to be able to correctly manage the system collective self-consumption inside the building.

Furthermore, the communication of data from the REC/MFR to the central server is continuously tested, which must be fluid and continuous.

Function(s) under Investigation (*FuI*)

"The referenced specification of a function realized (operationalized) by the object under investigation"

For each REC/MFR, the primary functions to be investigated are the electricity consumption of the shared systems of the systems/building (REC nodes, centralized heating system, common lights, ...), the electricity production of the installed photovoltaic system and the thermal consumption of the building in the heating season, which are significant as the heat production is entrusted to the electrically powered heat pump.

In addition to this, of fundamental importance is the investigation of the self-consumed electricity directly at the Point of Delivery (POD) of the centralized systems, from the heat pump in the first place, but also from the common accessory services (pumps, back-up boilers, common lights, …), of the energy purchased from the grid for these purposes and the excess energy

purpose) comparable, so as to be able to study them and highlight the goodness or weaknesses of each system built, in order to improve future interventions. Another required and fundamental feature to be obtained from data processing is the automatic calculation of energy flows from a single site, so that the incoming and outgoing energy flows of a single building can be seen, in order to view the functionality of this as a collective self-consumer and visualize the excess/lack of energy in each timestep. Having done this for each REC/building, the network of sites has to be implemented, in order to study the flows of electricity that would be possible, at a given time, between the various sites, as an energy community.

The aim is to create ***Smart Communities*** and "***Smart Building Ecosystem***" (**SBE**) that are capable of "*making interested Stakeholders understand*" the effects of possible changes in current energy regulation, based on real and used homes/dwellings that can be studied and evaluated, where it is possible to predict the effect of the installation of a new prosumer in the existent grid. A great result good-to-have will be the simulation of complex system of different buildings with their own energy flows, entering and exiting from the grid, simulating a possible real situation, and the how these changes affect the stability and the function of the system itself

Purpose of Investigation *(PoI)*

The test purposes classified in with terms Characterization, Verification, or Validation

The purposes of the test are the simulation of energy communities made of collective and non-collective

rules will change by May 2022, as RED-II Directive will eventually been adopted by the Italian government, making ERIGRID simulation and activities valuable for scenario analysis and business modelling). Since, due to the Italian Decree 199/2021 this regulation constraint is expected to be cancelled by the first half of 2022, it will be possible to create larger Energy Communities, where it is more interesting to simulate and understand energy flow management.

Functions under Test (*FuT*)

Functions relevant to the operation of the system under test, including FuI and relevant interactions btw. OuI and SuT

ergy output from the POD, which can be self-consumed by the PODs present in the condominium, sold to other PODs of the Energy Community or fed into the national electricity grid. Other functions worthy of interest are the parameters that can indirectly influence the aforementioned measurements, such as external and operating temperatures of the systems, which affect the performance of the latter and, consequently, on electricity consumption.	self-consumers, in order to verify the impact on the electricity grids and on the consumption and production of electricity of the buildings included in the simulation. Characterization: simulation of energy communities - that may also have dimensions exceeding the current legislative limitations- through the collection of energy data deriving from various REC prosumer-MFR through readings of energy data from different sites, with systems already implemented and data available and historicized, and their subsequent aggregation. Verification: implementation and processing of data deriving from the REC/MFR, control of the congruity of energy flows on the electricity grids concerned, the tolerance of the electricity system, effectiveness of collective self-consumption and simulation of "enlarged" energy communities, as they will be conceived in the coming years. Validation: validation of the building network model developed, through validation of the significance of the data arriving from individual REC node/MFR, of the convenience and usefulness in creating an energy community in a specific geographical area, in which there are buildings with photovoltaic systems, of the solidity of the model built for simulations	The most relevant functions in data sampling are the interfacing, using different protocols, with the devices in the field (e.g. Modbus, Bacnet, M-bus), using algorithms that allow the various REC Platforms/BMS systems installed in the different REC/MFR to be able to return the energy variables in the field on a single interface, these ones being the object of the study to the creation of a model of collective self-consumer, energy community and "expanded" energy community, which have a coherent unit of measurement and a significant value for the survey. Other "on site" functions include algorithms for calculating indirect values, such as the COP of the heat pumps installed, by reading the thermal and electrical energy values or the share of self-consumption for every user or the amount of electric energy exiting from the exchange POD but used in the home/building for REC/AUC purpose. Management and calculation algorithms are continuously developed and integrated into REC Platform/BMS controls to always ensure quality in measurements and integrate new functions or calculations Other functions include the communication of data to the centralized server, for supervision and control of the on-site systems (in order to intervene directly and promptly in the event of an anomaly) and the communication of data for the processing of the same and implementation within the simulations, using standard protocols to assure security and continuity in sending data and exchanging information.
Domain under Investigation (*DuI*): *''The relevant domains of test parameters and connectivity''* With reference to each controlled REC/MFR, the work domain referred to are distributed communities and residential building, whose boundary is represented by the common services such as the heating system, and common electrical installations. Each REC node and MFR, in fact, represents an independent system, capable of functioning as a collective prosumer and self-consumer with its own independent BMS for management and information collection purposes. The boundary here defined is the physical measurement boundary of the parameters relating to a single system (related to a POD) and MFR-BMS system, with all the measurement devices installed and electrically connected to each other, for which it is already necessary to verify the correct functioning and the electricity internal flows. The boundary widens sharply when we define the boundary of the energy community to be studied: in this case the boundary is represented by the limits of the current or future Energy Communities, when the current geographical limitations will lapse (MV/LV		

transformer, as stated by the current rules resulting from the adoption of RED-II Directive by the Italian government). This domain includes several sites, whose data must converge on a single platform and a single server, in such a way that they can be processed, taking into account the incoming/outgoing energy flows for each to be able to achieve the set goals.		
Target metrics (*TM*) *Measures retrievable from SuT required to quantify each of the identified test criteria* The main measures resulting from each REC/MFR are listed here. It is not possible to draw up a closed list, since RECs/buildings that are different from each other. However, it is possible to define some fundamental measures that will certainly be present at all REC/MFR: - Power and electric energy produced by photovoltaics - Power and electric energy consumed by the heat pump - Power and electric energy consumed by the building's common services (elevators, lights, ...) - Power and electric energy consumed by the thermal power plant (pumps, back-up boiler, ...) - Power and electric energy exchanged (in and out) with the grid - Electric Energy used as self-consumption from the REC nodes/building - Thermal energy generated by the heat pump - Thermal energy sent to users	**Test criteria** *(TCR)* *Formulation of criteria for each PoI based on properties of SuT; encompasses properties of test signals and output measures* The criteria for achieving the set objectives depend on the **availability of data for each REC/MFR**: in order to develop a simulation as realistic as possible of the system, it is obviously advisable to have the greatest number of data from the real site. The output signals derive from actual readings in the field through suitable meters. We take for granted that some parameters are essential and therefore will be always measured and integrated: e.g. the electricity production from the photovoltaic system (essential for the purposes indicated in the PoI, and always implemented). For other parameters, it is necessary from time to time to check on site the possibility of their integration and reading, for technical installation or privacy problems of the interested parties. Another criterion to consider is the significance of the data: some data implemented in the REC Platform/BMS systems on site may not be significant with respect to the outcome of the intervention: while, for example, the value of an external temperature can be important to verify the consumption of a heat pump running on electricity, less important for the PoI are,	**Variability attributes** *(VA)* *Identify relevant controllable or uncontrollable factors of the SuT and their required variability; refer to PoI* The controllable factors deriving from the SuT are represented by all the data carried out in the field and integrated on a single REC Platform/BMS support for the reading of these and for the management of the operation of the systems themselves. The REC/MFR are different from each other in terms of geographic location, size and installed systems, leading to different energy data, making the survey even more significant. Their main uncertainty depends on the fact that the object of investigation is represented by real, inhabited buildings, which may incur momentary accidental disruptions: unlike an experimental test in the laboratory, which is more controlled, in fact, a site (a condominium) can present greater uncertainties, such as, for example, a blackout situation that affects the operation of the REC Platform/BMS system or a temporary disruption on the telecommunications network does not allow data to be sent to the central server. Having already a fleet of installed and checked RECs and MFRs available, it has been seen that these are

- Seasonal average effective COP of the heat pump - System delivery and return temperatures - External temperature -…… For all these data the target is to create a database where you can compare these measures, to understand which are the parameters that influence the functioning of these systems (e.g. the producibility of a photovoltaic system based on geographical location, or the operating characteristics between different heat pumps, based on external conditions, etc,.). This database will already be useful in the study of collective self-consumption and the operation of an electrified heating system. Once the database has been created, it would be interesting to be able to view the different energy flows within a single site and between different sites, in order to see the best solution and the sizing of the systems with the aim of creating a well-balanced energy community. All data are continuously read in real time by the REC Platform/BMS system which makes them available for reading by the centralized system, so it is also possible to choose or vary the graininess of the reading. The meters installed have the Measuring Instruments Directive (MID) verification and certification that ensure the accuracy of the data collected.	again by way of example, the temperatures of a circuit of thermal solar panels. **Quality attributes** *(QA)* *Threshold levels for test result quality as well as pass/fail criteria* The test results are considered valid if, first of all, the systems installed on the various REC/MFR communicate without problems with the centralized servers, in order to continuously have data that can be studied, computed and aggregated. The threshold level in this case is to have a minimum communication of a data reception from each site once every hour, while the common target and the default is set to send every quarter of an hour. Secondly, it is necessary to certify the quality of the simulated system between multiple sites and the energy exchanges between them: it is necessary to see if a system does not lead to malfunctions on the electricity grid concerned, but also if the model itself can be consistent with reality, by number of actors involved. In this case it is not possible a priori to define a pass/fail threshold, but it will be necessary to comment on the results of the simulations to verify if the	situations that occur very rarely and quickly recovered. The data are in any case saved both in the REC platform central server and in the BMS on site, in addition to the fact that the energy data are cumulative on the meters installed. This redundancy minimizes the risk factors for the sites under consideration, in order to not impact and affect the results of the tests and investigations and on the final target indicated in PoI.

	consumption of self-produced electricity in an energy community is exploited as much as possible without introducing or withdrawing a large amount of electricity from the external network.	