Conformity assessment in Senegal: conformity tests in laboratories as the basis for Quality Infrastructure

Abstract:

This work focuses on quality infrastructure in the solar photovoltaic field in Senegal. On the one hand, it deals with the improvement of the quality infrastructure and on the other hand, conformity assessment accompanied by metrology and performance tests on batteries. We felt it was necessary to revisit the concepts of quality infrastructure and conformity assessment. Then in the improvement of this infrastructure metrology tests were carried out on electrical components by performing maximum error calculations to check the conformity on the voltage, the current, frequency and resistance of electrical quantities at a metrology laboratory, the LAME. We have also carried out compliance tests on batteries with the measuring equipment of the LCQS, a laboratory for testing photovoltaic solar components in Senegal. The study of the batteries covers two (2) elements in one cycle with a nominal capacity of 1080Ah. The capacities calculated after the tests performed on the two (2) elements are respectively C1(t)=1223Ah and C2(t)=1318Ah

Keywords: quality infrastructure, conformity assessment, current, voltage, performance analysis, Senegal.

1. Introduction

The question of energy is widely debated in the world, because of the growing gap between scarce supply and increasing demand. This imbalance is fuelling a widespread crisis that is having an impact on African economies, such as the rise in the price of a barrel of oil and the adverse effects of greenhouse gas emissions [1]. This crisis justified the frantic search for new forms of energy that are less costly and more environmentally friendly. It is in this context that renewable energy, particularly solar energy, is a source of hope for future generations in the face of increasing energy demand. However, these renewable energies must be managed by a good quality infrastructure to have a better energy service. To ensure an efficient and sustainable development of solar energy, we must consolidate the Quality Infrastructure (IQ) system for a good use of these resources [2]. This system includes public and private organizations and defines the policies, relevant legal and regulatory framework and practices necessary to support and improve the quality, safety and environmental soundness of goods, services and processes [3]. Quality infrastructure also means an approach that ensures the performance, sustainability and safety of components and facilities. Through its institutions and services, it provides the technical and operational bases essential to the functioning of modern societies. It is necessary for the efficient functioning of national markets, and its international recognition is important to allow access to foreign markets. Quality indicators support strategic objectives in areas such as industrial development, trade competitiveness in global markets, efficient use of natural and human resources, food security, health, climate change, environmental protection, and climate change mitigation and adaptation. It contributes to sustainable economic, ecological and social development in emerging and developing countries, which must meet certain conditions regarding their quality infrastructure [4].

Quality infrastructure institutions and their services can provide decision makers, businesses and other stakeholders with the knowledge and technical capacity to strengthen implementation, measuring and monitoring many of the goals and targets contained in the SDGs, and supporting actions to achieve them.

This concerns not only the respect of the instructions but also the competence to be able to relate his contributions to their elaboration. It includes essential elements to meet the needs of citizens of a country, consumers, businesses and any other structure that offers them goods and services.

All of this contributes to building user confidence, which in turn increases demand in this sector.

2. Conformity assessment

Conformity assessment refers to the processes and procedures used to demonstrate that a product, service, management system, organization or staff meets specific requirements. These requirements are typically identified in international standards developed by organizations such as ISO. The requirements for evaluation activities are themselves defined in international standards, thus ensuring global consistency and recognition of results. This enables the facilitation of trade between Senegal and exporting countries and contributes to the promotion of sustainable development in a significant way This evaluation is based on three (3) pillars which are inspections, testing laboratories and certification.

2.1. Inspections

The national inspection makes it possible to carry out the allows buyers to carry out quality control at the various stages of production and thus ensure that the products meet the requirements of their specifications and local regulations in force in the territory where they will be sold. Senegal has two (2) most outstanding institutions that carry out inspections and controls of products and companies. These institutions are the DCI (Directorate of Internal Trade) and the Bureau Veritas Senegal.

DCI conducts inspections on agri-food products, concrete for building construction among others and the Bureau Veritas Senegal which has been recognized and accredited by major national and international organizations. He works on several activities such as Certification, Buildings & Infrastructure, Inspections of installations & equipment in service (electrical installations-Elevators-Fire safety systems) [5]. Neither of these two (2) institutions do inspections on solar equipment. This means that imported PV products have various quality because there is still no real market surveillance to verify the quality of imported photovoltaic components This having as possible consequences the commissioning of photovoltaic installations not always safe, sometimes unreliable or with low yields.

2.2. Testing laboratories

Testing laboratories are necessary components of the quality infrastructure and are probably the most common type of conformity assessment since they provide the basis for making decisions on acceptance or rejection of the delivered goods, the definition of prices, the operation of machinery and equipment and other measures. The tests are carried out in most cases in laboratories equipped with appropriate instruments and in which the environmental conditions are maintained within the limits suitable for the tests concerned. The laboratory prepares for accreditation as a test laboratory in accordance with ISO 17025, which specifies the conditions of the equipment, the internal environment, the qualifications of the staff and the management system necessary to ensure the validity of the results.

2.3. Certification

Certification is the formal attestation that a product or process meets the requirements (which are often expressed by a standard). The certification of products and material processes is in most cases based on the systematic comparison of test and analysis results with the requirements specified in the standards or standard documents. It can be done for a single product, a batch of product, a service, a process or an installation. The certification body must have a high degree of confidence in the accuracy and impartiality of the work of the laboratories.

Thus mutual trust is an essential element of a cost-effective and effective conformity assessment; it can even be said to be the most important element [6]. Company management systems are also certified, for example, the quality management system according to ISO 9001, the management of food safety according to ISO 22000, environmental management according to ISO 14001[7].

3. Tests at the Metrology Laboratory (LAME)

Metrology is the science of measurement. It defines the principles and methods for ensuring and maintaining confidence in the measures resulting from measurement processes. For example, if we send a voltage of 12V to a calibrator and we find 14V, it means that there is a measurement error caused by the calibrator. The correction will be done by metrology. Maximum error calculations to verify compliance on voltage, current, frequency and resistance are important, allow to take into account all the physical constraints related to the measurement that it adds to the measured value to conclude whether the measurement is actually compliant or not. Compliance with this measure depends entirely on the maximum permissible error. The calibration study on electrical quantities is done in the African Laboratory of Metrology and Test LAME.

3.1. Equipment Used

The equipment used to perform the tests are the multifunction calibrator (Figure 1), the Flucke multimeter (Figure 2). We also have the 5080A/1020V DC/AC multifunction calibrator (multimeter calibration up to 3.5 digits). It is easy to use as it can handle a large flow calibration workload such as:

- Analog meters;
- Panel counters;
- Digital multimeters;
- Watt meters;
- Clamps (with coil accessory);
- Megohm meters (optional);
- 200MHz oscilloscopes (optional).

3.2. The test protocols

An example of calibration with multimeters was taken for the multi-function calibrator. In AC voltage the calibres are 50 to 500mv and for volts are 5, 50, 500 and 1000.

- For 50mv the resolution is three (3) digits after the comma. Here we take three positives and two negatives because it corresponds to the direct caliber and we do not take the value greater than 50mv because it can change the uncertainty, the resolution and the precision.
- For 500mv the resolution is two digits after the comma. Here we take a positive point and a negative point because it does not correspond to the direct caliber and we do not take the value 500mv with the same justification.
- For 5V the resolution is four digits after the comma. This is the most accurate caliber.

The same procedure is done with the other gauges in DC voltage, AC and DC current and then in resistance. They vary. The higher the resolution, the better the calibre.

$$Error = Instrument\ Value - Standard\ Value$$

$$EMT = Accuracy\ in\,\% * Standard\ value + Digit * Resolution$$

Figure 1: multifunction calibrator

Figure 2: the Flucke multimeter

3.3. Results and Discussions

The results obtained are included in Tables 1, 2, 3, 4 and 5.

Based on the results we obtained on the tables above; all judgments are consistent. This is due to the acceptability of the results of the maximum values to be tolerated We have based on the data specifications of the consultant. The BLADE derives a calibration certificate, gives the results obtained to the client and leaves him to make his decision in relation to the result attributed to him.

All this is important, but we need to have reference material on the solar equipment needed for us to do the same, so that we can have reliability on the results we will get during the tests. All this will allow us to ensure the functionality of some photovoltaic laboratories in the technical field.

Table 1: continuous voltage measurement

Caliber	Unity	Standard Value	Instrument Value	Error	Uncertainty	EMT	Conclusion
50	mV	-40,000	-40,043	-0,043	0,000577	0,22	Conformity
50	mV	40,000	39,959	-0,041	0,000577	0,22	Conformity
500	mV	-400,00	-400,07	-0,07	0,005774	0,12	Conformity
500	mV	400,00	399,94	-0,06	0,005774	0,12	Conformity
5	V	-1,0000	-1,0001	-0,0001	0,000082	0,0005	Conformity
5	V	1,0000	0,9999	-0,0001	0,000058	0,0005	Conformity
5	V	2,0000	2,0000	0,0000	0,000082	0,0007	Conformity
5	V	-4,0000	-3,9999	0,0001	0,000058	0,0012	Conformity
5	V	4 ,0000	4,0000	0,0000	0,000082	0,00	Conformity
50	V	-40,000	-40,001	-0,001	0,000577	0,01	Conformity
50	V	40,000	40,002	0,002	0,000577	0,01	Conformity
500	V	-400,00	-400,02	-0,02	0,008165	0,14	Conformity
500	V	400,00	400,02	0,02	0,005774	0,14	Conformity
1000	V	-900,0	-899,9	0,1	0,0057735	0,47	Conformity
1000	V	900,0	900,0	0,0	0,057735	0,47	Conformity

Table 2: alternative voltage measurement

Caliber	Unity	Frequency	Standard Value	Instrument Value	Error	Uncertainty	EMT	Conclusion
50	mV	50Hz	40,000	39,994	-0,006	0,076424	0,145	Conformity
500	mV	50Hz	400,00	399,89	-0,11	0,340049	1,45	Conformity
5	V	50Hz	1,0000	1,0025	0,0025	0,000852	0,006	Conformity
5	V	100Hz	1,0000	1,0016	0,0016	0,000852	0,006	Conformity
5	V	1000Hz	1,0000	1,0016	0,0016	0,000852	0,006	Conformity
5	V	50Hz	2,0000	2,00	0,00	0,006023	0,256	Conformity
5	V	100Hz	2,0000	2,0024	0,0024	0,001701	0,009	Conformity
5	V	1000Hz	2,0000	2,0027	0,0027	0,001701	0,009	Conformity
5	V	50Hz	4,0000	4,0033	0,0033	0,0056	0,015	Conformity

5	V	100Hz	4,0000	4,0045	0,0045	0,005603	0,015	Conformity
5	V	1000Hz	4,0000	4,0051	0,0051	0,0056	0,015	Conformity
50	V	100Hz	40,000	40,050	0,05	0,048007	0,15	Conformity
50	V	1000Hz	40,000	40,056	0,056	0,0488017	0,15	Conformity
500	V	1000Hz	400,00	400,64	0,64	0,480069	1,45	Conformity
1000	V	1000Hz	900,0	901,3	1,3	1,081542	5,2	Conformity

Table 3: direct current measurement

Caliber	Unity	Standard Value	Instrument Value	Error	Uncertainty	EMT	Conclusion
500	A	400,00	400,05	0,05	0,308054	0,5	Conformity
5	mA	4,000	4,002	0,002	0,002151	0,005	Conformity
50	mA	40,000	39,997	-0,003	0,015611	0,03	Conformity
400	mA	300,00	299,96	-0,04	0,117142	0,47	Conformity
5	A	2,0000	1,9997	-0,0003	0,000782	0,007	Conformity
5	A	-4,0000	-4,0003	-0,0003	0,001565	0,013	Conformity
5	A	4,0000	4,0003	0,0003	0,001588	0,013	Conformity
10	A	9,000	9,003	0,003	0,003604	0,029	Conformity

Table 4: alternating current measurement

Caliber	Unity	Frequency	Standard Value	Instrument Value	Error	Uncertainty	EMT	Conclusion
500	µA	50Hz	400,00	400,40	0,4	1,60127	2,6	Conformity
5000	µA	50Hz	4000,0	4003,4	3,4	16,000104	24,5	Conformity
50	mA	50Hz	40,00	40,03	0,03	0,06426	0,44	Conformity
400	mA	50Hz	300,0	300,2	0,2	0,48346	2,3	Conformity
5	A	50Hz	2,0000	2,0009	0,0009	0,0066	0,018	Conformity
5	A	50Hz	4,0000	4,0034	0,0034	0,0168	0,034	Conformity
10	A	50Hz	9,000	9,007	0,007	0,037804	0,077	Conformity

Table 5: resistance measurement

Caliber	Unity	Standard Value	Instrument Value	Error	Uncertainty	EMT	Conclusion
500	Ω	190 ,00	190,05	0,05	1,190088	1,05	Conformity
5	KΩ	1,0000	1,0004	0,0004	0,001002	0,0052	Conformity
5	KΩ	1,9000	1,9006	0,0006	0,001901	0,01	Conformity
50	KΩ	10,000	10,003	0,003	0,010017	0,052	Conformity
500	KΩ	190,00	190,08	0,08	0,190088	0,97	Conformity
5	MΩ	1,000	1,003	0,0003	0,001002	0,005	Conformity
5	MΩ	1,900	1,901	0,001	0,001986	0,014	Conformity
30	MΩ	19,000	19,012	0,012	0,019009	0,289	Conformity
500	MΩ	100,0	100,4	0,4	0,129099	8,2	Conformity

4. Testing of solar batteries in the test laboratory

Solar PV installations are very often expensive. Unfortunately, the drop in performance observed in these systems remains a major concern for research in the field of solar photovoltaics. These performance losses can be due to several factors such as the quality of the components to be installed (panels, batteries, inverter controllers) or their degradation that may occur during the operation of PV systems. In this part we will perform tests on batteries to study their performance after several years of operation.

4.1 The equipment used

The customer's battery fleet consists of two 1080Ah – 48V battery chains. Each chain consists of 24 2V – 1080Ah HOPPECKER OPzV1000 series elements (Figure 3).

Figure 3: the two battery chains

The service life of these elements under ideal operating conditions is 20 years. Their characteristics are:

- Capacity (C100 = 1080 Ah)
- 1500 cycles at 80% discharge
- 2500 cycles at 50%
- 4500 cycles at 30%
- Short circuit current: 6460 A
- Internal resistance: 0.32 ohm
- Weight: 82 kg

To perform compliance testing, we will use:

- Electronic charge
- Data logger Squirrel 2020 measurement and acquisition device
- Connection cables
- Shunt resistance

4.2 The test protocol

The electrochemical storage facility consists of two chains of 1080Ah-48V batteries. Each battery has 24 2V elements with C100 = 1080Ah capacity, connected in series. For the test we took two samples with each sample from a chain.

The electronic load we have to perform the tests allowed us to discharge with a maximum current of 10A. Under these conditions, the duration of a discharge would be around 100h (more than 4 days). We have chosen the option to do a charge/discharge cycle. The measurement and data acquisition device used is the Grant brand Squirrel 2020 Data Logger. For the discharge of the battery element, we used an electronic charge of 20A and the recharge is made thanks to a stabilized DC voltage source. The tests were performed as follows (Figure 4):

Figure 4: battery test assembly

4.3 Results and Discussions

The declared capacity of the OPzV1000 element being C100 = 1080Ah, the duration of the test could equal 100h.

Sample 1: We recharged it for 24h then discharged at constant current and set the discharge intensity to 10A, on 10/06/2021 at 16:40 hours. The results are presented in Table 6.

At the end of the discharge, the capacity extracted from the battery reached 1223Ah at the shutdown voltage of 1.8V, under an average temperature of 33°C.

From these results we can say that the element thus tested, representing the first battery is in good working condition.

Sample 2: This second element was recharged for more than 24 hours and then discharged at constant current on 17/06/2021 at 09:25 minutes. The discharge intensity is set at 10A. The results are presented in Table 7.

At the end of the discharge, the capacity extracted from the battery reached 1318Ah at the 1.8V shutdown voltage, under an average temperature of 33°C.

From these results we can say that the element thus tested, representing the second battery is in good working condition.

Table 6: sample 1 test results

Sample 1	Date/Time	Voltage (V)	Capacity discharge (Ah)	Fixed Current (A)	Mean discharge current (A)
Begin of discharge	10/06/2021 16h40mn	2,1	0	10	9,6
End of discharge	15/06/2021 11.50pm	1,8	1223		

Table 7: sample 2 test results

Sample 1	Date/Time	Voltage (V)	Capacity discharge (Ah)	Fixed Current (A)	Mean discharge current

					(A)
Begin of discharge	17/06/2021 09h25mn	2,1	0	10	10,0
End of discharge	22/06/2021 16h20mn	1,8	1318		

We can conclude that the tests required for the batteries took place over several days because the C100 capacity is only reached after 100 hours of discharge with a constant current of 10A. We chose to test 2 OPzV1000 elements, each element representing a battery chain that each has 24. The capacities calculated after the tests carried out on the two elements are respectively:

- C1 (t) = 1223Ah at an average temperature of 32°C and a shutdown voltage of 1.8V, for item 1 and,
- C2 (t) = 1318Ah at the mean temperature of 30°C and the 1.8V shutdown voltage, for element2.

These results show that the battery components of the electrochemical storage plant at the UCAD Faculty of Science and Technology are in good working order. In short, the energy production and storage elements of the solar power plant of the Faculty of Science and Technology of the UCAD are in good working order.

8. Conclusion

Senegal is not a country that produces solar equipment. It is therefore at the time of its importation that the quality must be checked. This is why we have done conformity tests to check the condition of solar photovoltaic equipment and electrical measuring devices. But the aging of some equipment leads to a decrease in their performance. As a result, many recommendations were made at the level of tests but also at the level of electrical measurement components.

How can we achieve lasting effects on our imported materials? Will we achieve satisfaction when our quality infrastructure is complete? These are all questions that deserve everyone's reflection.

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