FOTOVOLTAICA UFSC:
Solar Energy Research and Training Center of
Universidade Federal de Santa Catarina
www.fotovoltaica.ufsc.br

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[R&D ENGIE/UFSC – Technical Specification for 100 kWh Lithium-Ion Energy Storage System (ESS)]

"Hiring of an engineering firm to supply materials and to install an energy storage system (turn-key mode) with integration to the electrical grid and communication network of the Laboratory Fotovoltaica - UFSC."

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1. INTRODUCTION

This document presents the Technical Specifications (TS) along with the basic requirements for the materials, equipment, documentation and related services to be provided and executed for the installation, testing and commissioning of a 100 kWh turn key Energy Storage System (ESS), with an alternate voltage output connected to the laboratory Fotovoltaica-UFSC. The energy storage system will be installed in a container at the Building C of the Fotovoltaica - UFSC laboratory, located at Av. Luiz Boiteux Piazza, n° 1302, Sapiens Parque, in the neighborhood of Cachoeira do Bom Jesus, in Florianópolis, Santa Catarina.

The present document does not exhaust all the requirements and specifications nor all the necessary items to properly execute of all services, supply the materials and equipment to achieve a perfect execution, operation, assembly and performance of the ESS. Therefore, the list of items contained herein should be interpreted as a general guideline and with minimal requirements. This list also not relieve the **CONTRACTOR** from including, in the presented proposal, the detailed description of all items, services and materials, even if not specifically mentioned, in order to ensure proper and continuous operation of the ESS, as well as all auxiliary systems and accessories.

All materials, equipment, facilities, civil services and other items necessary for the proper installation, completion and continuous operation of the ESS, as well as all auxiliary systems and accessories, will be included in the **CONTRACTOR's** scope of work and in the value of the **CONTRACT**, unless otherwise specified.

The **CONTRACTOR** for the implementation of the ESS will be responsible for elaboration of the executive project, supplying all materials and equipment and for all mechanical and electrical installations, delivering the ESS fully operational (turn-key mode).

The ESS is part of the ENGIE/UFSC R&D project after a call for R&D projects (021/2016) by ANEEL.

2. OBJECTIVE

This technical specification aims to define the scope, minimum requirements and basic guidelines for the **CONTRACTOR** to submit a proposal for the execution of services related to the implementation of the ESS on the premises of Fotovoltaica-UFSC laboratory, located in Avenue Luiz Boiteux Piazza, lot 116, in the neighborhood of Cachoeira do Bom Jesus, Florianópolis, SC (coordinates -27.4309125,-48.4412691).

The activities contemplated in this TS are detailed throughout the document, consisting of the following steps:

a) Elaboration of the executive project;
b) Execution of the services - equipment installation and commissioning;
c) Assisted operation and maintenance of the energy storage system during the validity of the contract;
d) Training and technical capacitation of members of Fotovoltaica - UFSC laboratory for the operation and maintenance of the energy storage system.

In addition to the rules and regulations that govern these systems, the **CONTRACTOR** must consider the applicable legislation and the specific rules of the local electric utility, also assuming and declaring that they are aware of the interventions to be carried out.

3. GENERAL CONSIDERATIONS

It is of the **CONTRACTOR's** entire responsibility to comply with the specific project conditions, including the equipment purchase specifications. Even if there are differences due to issues that cannot be verified at the time of execution, accepted as justification by a UFSC representative, it will be up to the **CONTRACTOR** to review, where applicable, the respective project and implement the change posteriorly, with the approval of the **CONTRACTING PARTY**, without additional burden the **CONTRACTING PARTY**.

The **CONTRACTOR** shall be solely responsible for the right and authority to resolve any and all individual cases and omissions in this TS, the provided projects and other technical and contractual documents.

In the existence of non-described services, the **CONTRACTOR** can only proceed to execute them after the approval of a representative of the **CONTRACTING PARTY**. The omission of any procedure and/or standards in this or other memorials, projects, or other contractual documents, does not exempt the **CONTRACTOR** from the obligation of using the best techniques in the execution of the defined services, respecting basic objectives of functionality and adequacy of the results, as well as all current and relevant ABNT (*Associação Brasileira de Normas Técnicas - ABNT*) regulations.

It cannot be argued as justification or defense, in any case, by the **CONTRACTOR**, ignorance, misunderstanding, doubts or forgetfulness of clauses and conditions contained in this technical specification, as well as all that is contained in ABNT regulations, specifications and methods and other relevant standards.

In case of discrepancies, the special conditions of the contract, general technical specifications and memorials predominate over the project, as well as the specific projects in each area predominate over the general ones of other areas, specific details predominate over general ones and quotas must predominate over the scales. Any discrepancy must be communicated in good time to the **CONTRACTING PARTY**, for the necessary measures and compatibilization.

In case of discrepancies or lack of specifications of brands or models of materials, equipment, services and finishes, it should always be observed that these items should have a minimum quality level and that the specific product should always be approved in advance by UFSC.

The specifications, project drawings and the descriptive memorials are the description and execution of the services completely finished under the terms of this TS with all elements in perfect working condition and finishing quality. Therefore, these elements should be considered complementary to each other, and what is included in one document is as obligatory as if it were included in all others.

The **CONTRACTOR** accepts and agrees that the services objectified in the contractual documents should be complemented in all the details, even though each item involved may not be necessarily specifically mentioned.

The **CONTRACTOR** shall make all corrections, interpretations and compatibilization that are deemed necessary for the completion all services in a satisfactory manner, always in conjunction with a UFSC representative designated to follow up on project management.

The **CONTRACTOR** may previously visit the ESS implementation site and inspect the general conditions of the terrain, accesses, constructions and neighboring construction sites, various facilities, existing services to be performed, feeds and removals of installations, passages, derivations, interconnections, as well as verifying quota and other dimensions of the project, comparing them to measures "in loco".

If the **CONTRACTOR** decides not to carry out the visit, it may not claim any type of disadvantage or lack of knowledge.

The proposal must contain all items not included in the TS or in the estimated worksheet provided, in addition to complements and/or changes in layout, reinforcements, reconstitutions, fillings, coatings and regularizations, infrastructures necessary for the assembly of specific equipment, as well as all the necessary adaptations to the completion of all services, with no additive term aiming to add such items after the signing of the agreement.

Any differences and doubts will be resolved before the start of any body of work and services.

The **CONTRACTOR** shall submit, before the beginning of the ESS implementation, a list of the names and documents of all employees who will be working on the project. During work, all employees must be properly identified (visible tags), in uniform and with complete Personal Protective Equipment (PPE).

The contract must be duly registered in the Santa Catarina Regional Engineering and Agronomy Council - CREA-SC, under the responsibility of a professional duly qualified to carry out the scheduled activities.

Any criteria/method of execution of this service, different than that mentioned in the documents that comprise the project, will only be executed with prior authorization from UFSC and non-compliance will subject the **CONTRACTOR** to bear the burden arising from the consequences of this action.

The **CONTRACTOR** shall follow the applicable safety standards and regulations, as well as provide all tools and/or equipment necessary for the execution of the services, including Individual and Collective Protection Equipment.

3.1. PROJECT DOCUMENTS

It is the responsibility of the **CONTRACTOR** to observe the following requirements, regarding the project documents:

- All documents, including reports, must be written in Portuguese;
- The regulation and/or technical reference applied to different aspects of the project should be clearly indicated;
- All documents, drawings, diagrams, graphs, tables, etc., which constitute the project documents, should make use of the International System of Units (Metric Decimal System). If another system of units is used, the conversion to the International System must be indicated in a side note;
- All studies should be elaborated in accordance with rules and regulations of Brazilian technical standards (priority) or international, in their last revisions;
- All calculations contained in the project documents should be displayed;
- All recorded measurements utilized in calculations or other project activities, shall be submitted.

All documents in digital media must be compatible with Windows operating system and Office applications.

After approval of each step, all documents must be provided in 02 (two) printed and digital media. The documentation must be delivered in 03 (three) printed and digital media.

3.2. HORIZONTAL AND VERTICAL TRANSPORTATION

All horizontal and vertical transportation services required at all times during the duration the provided services will occur at the **CONTRACTOR's** expense.

3.3. APPLICABLE STANDARDS - MATERIALS AND SERVICES

All equipment, materials and services supplied or indicated for purchase by the **CONTRACTOR** shall comply with current technical standards and regulations, corresponding to the minimum parameters to be met. Brazilian official standards prevail over international norms.

For the storage system, the following standards and procedures must be met:

- IEC 62485-2 - Safety Requirements for Secondary batteries and battery installations – Part 2 stationary batteries;
- IEC 61427-1 - Secondary cells and batteries for photovoltaic energy systems (PVES) – General requirements and methods of test;
- IEC CDV 62620 - Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for use in industrial applications;
- IEC 62620 Ed 1 - Large format secondary lithium cells and batteries for use in industrial applications;
- UL 1642 - Lithium Batteries;
- IEC 62040-1 Ed2 - Uninterruptible power systems (UPS) – Part 2: General and safety requirements for UPS installed in restricted access locations;
- IEC 62897 - Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements (under development);
- IEC 62933 - EES systems – Terminology;
- IEC 62936 - Environmental issues of EES systems;
- IEEE 1375 - Guide for the Protection of Stationary Battery Systems;
- UL 1778 - Uninterruptable Power Sources;
- IEC 62935 - Planning and Installation of Electrical Energy Storage Systems;
- IEEE/ASHRAE 1635-2012 - Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications;
- NFPA 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate;
- IEC 62485-1 Ed 1 - Safety requirements for secondary batteries and battery installations – Part 1 General safety information;
- IEC 62485-2 - Safety requirements for secondary batteries and battery installations. Part 2: Stationary batteries.

All materials and/or equipment provided by the **CONTRACTOR** must be of the highest quality levels, satisfying ABNT, INMETRO and possibly other entities specifications. It should be noted

that all the equipment to be installed must present the highest value of the PROCEL seal or the energy efficiency label, when applicable.

If the equipment specified in the project has been discontinued or is obsolete at the time of the implementation of the project, it must be replaced by the corresponding current model, provided that it complies regarding efficiency, equivalence and compliance with the conditions established in the projects, specifications and contract.

The use of used and/or damaged materials and/or equipment will not be allowed. It is also forbidden to use improvised materials and/or equipment, replacing those technically indicated for the purpose for which they are intended. Furthermore, it will not be tolerable to adapt parts, either by cutting or other processes, in order to use them in place of recommended parts.

When there is substantial reason to substitute a specified material and/or equipment for another, the **CONTRACTOR** shall, in due time, submit the replacement proposal in writing, instructing it with the reasons given in the comparative budget request, according to what agreement between the parties on equivalence, and the **CONTRACTING PARTY** shall decide to accept or not the request. The study and analysis by the **CONTRACTING PARTY** of the substitution requests will only be made when the following requirements are met:

- Declaration that the substitution will be made without charge to UFSC, in the case of materials and/or equipment.
- Indication of trade mark, manufacturer name or commercial type, which are intended to define the type and quality standard required.

4. SCOPE OF SERVICES

4.1. OBJECTIVE

This document presents the TS of the equipment necessary for the implantation and connection to the local utility grid of an energy storage system with all its auxiliary electrical and fire protection, and monitoring systems to be installed in a container on the ground floor of the Building C of the laboratory Fotovoltaica-UFSC laboratory, located at Av. Luiz Boiteux Piazza, n°1302, Sapiens Parque, in the neighborhood of Cachoeira do Bom Jesus, in Florianópolis, Santa Catarina.

4.2. LOCATION

The energy storage system will be installed on the ground floor of the Building C of the Laboratory Fotovoltaica-UFSC. The container disposition, or of the own system in case it's not containerized, is shown in FIGURE 1. The container must have 20 standard feet with dimensions of 6.058 x 2.438 x 2.591 (Length x Width x Height in meters).

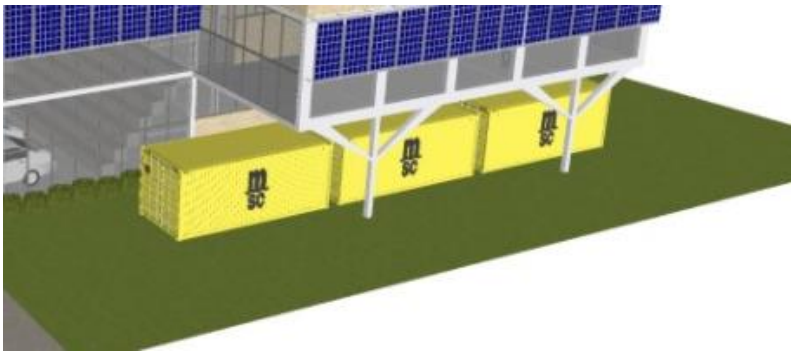


FIGURE 1 - CONTAINER FOR THE ENERGY STORAGE SYSTEM INSTALLATION

The arrangement of the storage system can be seen in **FIGURE 2.**

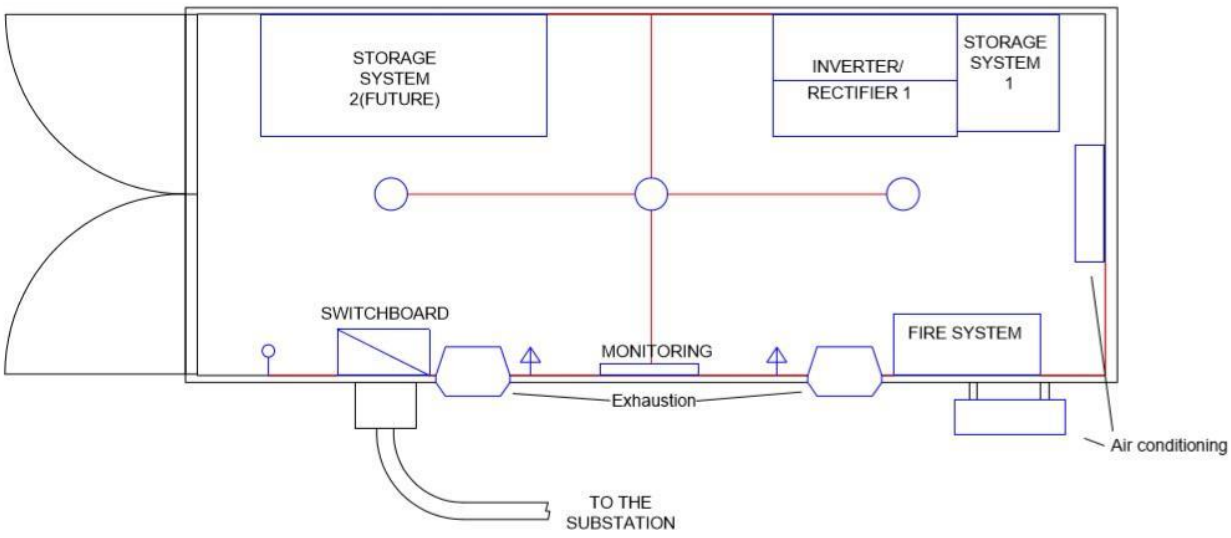


FIGURE 2.DISPOSITION OF ENERGY STORAGE SYSTEM COMPONENTS

4.3. COMPOSITION OF THE ENERGY STORAGE SYSTEM

The energy storage system is composed of a set of batteries with a minimum capacity of 100 kWh with all the necessary elements for its connection with the alternate current (AC) grid of the laboratory Fotovoltaica - UFSC in a safe way through devices of electrical and fire protection with monitoring through a supervisory system with real time acquisition, user interface and data storage.

4.4. ENERGY STORAGE SYSTEM AND BMS

The installed capacity of the storage system should be at least 100 kWh with integrated BMS capable of monitoring the state of charge of its individual cells and acting in contingencies of overvoltage and undervoltage, short circuit and inversion of polarity.

The batteries should be $LiFePO_4$, a prominent technology in the market and safer as it doesn't use heavy metals as cobalt and titanium in its composition.

4.5. RECTIFIERS AND INVERTERS

The rectifier and inverter circuit of the storage system shall have a nominal power of at least 100 kW (a unit factor C for the system capacity).

The equipment must allow operation functionality while off grid, where the system shall remain connected to supply the loads of the building, Forming a stable grid with all the other PV inverters that are already installed on the building. The system should also allow parallel operation with the public electricity grid, allowing the charging and discharging of the battery connected to the grid AC bus, according to remote commands.

TABLE 1 presents the guiding parameters used in the basic design of the system, indicating the characteristic minimum values for the performance parameters of the equipment.

TABLE 1. MAIN FEATURES OF RECTIFIERS/INVERTERS

Feature	**Specification**
Rated Power	≥ 100 kVA
Frequency	60 Hz
Permissible maximum temperature	40°C
Relative humidity (non-condensing)	< 95%
Maximum system efficiency (load/discharge)	> 97,5%
Power factor (cos φ)	Adjustable ± 0,8

4.6. FIRE PROTECTION SYSTEM

The container must be equipped with an automatic fire detection system and a fire suppression system through chemical NOVAC 1230, FM 200 or similar. In the event of a fire, the system shall transmit an audible alarm and signal to be sent through the supervisory system.

The container's exhaust system should also be triggered automatically by anomaly detections in the storage system.

The **CONTRACTOR** shall provide adequate training for fire and risk situations.

4.7. HVAC

HVAC units must supply the cooling capacity of the battery container. The allowed temperature range within the battery compartment is typically between 10 ° C and 40 ° C, without any operational restrictions. When it comes to configuration settings, the recommended setups are vertical wall-mounted packaged and split unit.

The temperature inside the power converter and the control panel housing must remain in the temperature range between 10 ° C and 40 ° C. Thus, the operation of the HVAC system must be conditioned to the storage system, operating only when the storage system is put into operation.

The maximum internal humidity established for this type of application is 95%. Condensation inside the container must not be allowed.

The system must also provide an alarm system capable of notifying locally and remotely when there is a problem in the HVAC system (through the use of temperature and humidity sensors). In case of alarm, the general system of the container will be switched off immediately.

4.8. SINGLE-LINE DIAGRAMS

The storage system, comprised of the battery bank, inverter/rectifier system and its auxiliary systems must all be connected through a distribution board located inside the container. Its connection follows the single line shown in FIGURE 3.

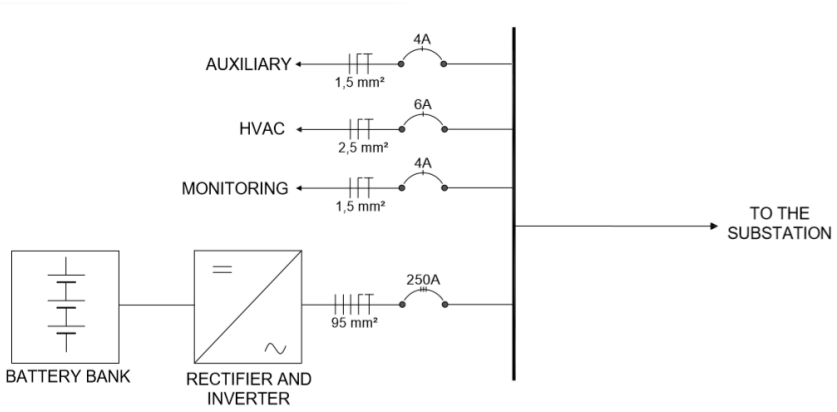


FIGURE 3. SINGLE-LINE DIAGRAM OF THE ENERGY STORAGE SYSTEM AND ITS AUXILIARIES

The connection of the storage system to the ESS framework is the responsibility of the **CONTRACTING PARTY**.

4.9. COMMUNICATION

Communication of the system shall be performed using Ethernet communication or another mode in order to connect the battery bank monitoring system to the data acquisition and analysis system (DAAS) datalogger. The entire communication project shall be the responsibility of the **CONTRACTOR** and shall be submitted in advance for approval by the **CONTRACTING PARTY**.

The communication system must have its own supervisory system, which contains the main operating information of the battery bank, such as voltage, power flow, state of charge, state of life, temperature, activation and etc.

The battery bank variable measurement system must have RS485 MODBUS communication for real-time reading by the internal monitoring system.

The provision of CAT 6 network cables, adapters, converters and any other equipment for proper operation of the communication system is the responsibility of the **CONTRACTOR**.

The Data Acquisition and Analysis System (DAAS) is composed by the battery measurement system, supervisory system for monitoring and the datalogger for recording and storing the data of the measurement systems involved. DAAS must be configured to record the ESS electrical and environmental data.

4.10. ELECTRICAL INSTALLATION

The electrical design of the storage system must be elaborated based on the pertinent norms and standards and must have ART registered in CREA-SC. Conductors, connectors and conduits must be dimensioned and installed according to their capacity defined by Brazilian norm NBR 5410.

4.10.1. Electrical conductors

The conductors must be dimensioned respecting the maximum permissible ampacity. A maximum total voltage drop of 2% is allowed on the AC cabling as a whole.

Electrical conductors leaving the containers distribution board to power the HVCA and auxiliary monitoring circuits shall have a cross-section equal to or greater than 1.5mm² and shall have a minimum insulation of 1kV.

Conductors must be weather protected, not propagate flame and be of halogen free material with low emission of smoke and toxic gases.

4.10.2. Connectors

The connectors must have eyelets with pre-insulated terminals. Amendments should be avoided and, when necessary, performed using solder, self-fusing tape and retractable thermo-tube with UV protection.

4.10.3. Cable installation

Conductors must be installed in appropriate locations. It must be ensured that the chosen location does not collect water, which could damage not only the cables, but also the connectors. Cables should be prevented from being loose or over tensioned and ensured that the same do not suffer from strangulations.

In addition to being protected against water and the incidence of UV radiation, the cables should be out of reach and should not interfere visually with the architecture and exposure. They must run on conduits, electrodes, on linings or inside shafts, at the discretion of the **CONTRACTING PARTY**.

4.10.4. Conduit / Electrical ducts

For the cables leaving the distribution board in the inner area of the container, metal conduits or metal electrodes may be used. The electrodes shall be dimensioned so as not to exceed the maximum occupancy rate and shall be manufactured in SAE 1010/1020 steel sheets (with electrolytic galvanizing in accordance with standard Brazilian NBR 10476/88) or in aluminum. The electrodes shall be properly grounded. All cables should be installed juxtaposed horizontally.

4.10.5. Distribution board

The storage system container will have an electrical panel located on the inside. The board must have circuit breakers and DPS.

4.10.6. Circuit breakers and Residual Circuit Breakers (RCB)

The executive project shall predict that all low voltage AC protections must be specified as such: thermomagnetic circuit breaker, front control knob, contact position signaling, dimensioned with interruption capacity according to each circuit. Circuit breakers must comply

with IEC 60947-2 and NBR 5410/2004. A 250A protection circuit breaker must be used inside the substation.

The distribution board must have a circuit breaker for the auxiliary circuit, one for the HVCA circuit and one for the monitoring circuit, as shown in FIGURE 3. A 250A protection circuit breaker must be installed in the distribution cabinet to ensure the protection of the battery bank.

4.10.7. Grounding

The entire system must be grounded, including the electrodes and the housing of the storage system container. The **CONTRACTOR** shall carry out the design and execution of the grounding system. The sizing criteria must meet the conditions of electrical continuity, contact/step voltages, conductor temperature and protection against indirect contacts established in the Brazilian NBR 5410 norm.

All grounding shall be connected to an bonding busbar in the grounding grid of the Building B, located near the container.

4.10.8. System Identification

All components of the storage system shall be properly labeled and identified, including:

- Identification of all circuits, protection devices, switches and terminals.
- Identification of the AC distribution board.
- Identification of the storage system (batteries and peripherals).

5. EXECUTIVE PROJECT

The Executive Project shall present the necessary elements for the implementation of the project to install the energy storage system in block C of the laboratory Fotovoltaica-UFSC in Florianópolis, including the actions of execution, materials and equipment to be used, and technical documentation required for further operation and maintenance.

The **CONTRACTOR** shall prepare the executive project and the execution planning of the project following the guidelines provided by this document.

Its reading should allow the perfect understanding of what will be accomplished for the implementation of the project, including Descriptive Memorial, AutoCAD Drawings, Typical Details, Flowcharts, Single-line Diagrams, Multifilament Diagrams, Schematic Drawings, Equipment Technical Specifications and Physical and Financial Schedules.

In order to detail the alternatives to be implemented, all necessary technical aspects, including current standards and legislations, as well as service's characteristics regarding maintenance viability, especially corrective ones involving component replacement, should be taken into account.

The **CONTRACTOR** shall prepare the ESS Executive Project, where which digital and printed versions will be provided:

- Listing of all equipment and materials of the ESS, informing the brand, model and technical specifications, and providing catalogs.
- General site plan with the location of the storage system and auxiliary systems.
- Detailed plans for all equipment including DAAS components.

- Single-line diagrams of the data acquisition system (DAAS), containing data and power cable connections, as well as sensor connections.
- Electrical project containing the sizing of all components of the storage system, such as conductors, protection systems, measuring systems, circuit breakers, disconnectors, etc.
- Safety project containing warning signs regarding the risks at the site;
- Schedule of the projects execution in MS Project;
- All Calculations required of all submitted projects.

All information presented in the Executive Project must be in Portuguese and follow current Brazilian standards for the electrical and safety sector.

The **CONTRACTOR** must provide to UFSC, prior to commissioning, the Operation and Maintenance Manuals and drawings under review "as built". All of these documents will be provided by the **CONTRACTOR** in 5 (five) printed copies and 5 (five) digital copies (CD or DVD).

5.1 CONSTRUCTION AND INSTALLATION

The **CONTRACTOR** shall provide in its proposal the following items:

- Acquisition of the necessary equipment for the installation, including storage system and inverters.
- Equipment transport and delivery.
- Execution of the necessary civil work (passage of conduits, installation of electro ducts, adjustment of the electric rooms of the investors, etc.).
- Construction of the physical installations of the photovoltaic system, comprising: electrical installations (gutters, cables, etc.), fire-protection equipment and individual protection.
- Checking the connection points.
- Installation of the ESS and inverters.
- Installation of the DAAS.
- Connection of the photovoltaic system to the local utility grid.

5.2 ELABORATION OF THE TECHNICAL DOCUMENTATION (TD)

The **CONTRACTOR** shall prepare and provide the Technical Documentation (DT), in Portuguese, containing diagrams, plans and all information regarding the ESS, updated after its installation, i.e. as built. In addition to data and information on the ESS, the TD will include a Basic Operation and Maintenance Manual, which will guide the operation and maintenance personnel, and the "Accident Management and Safety Manual".

Elaboration of the TD must be in accordance with the items and sub-items specified below, which should be expanded with the inclusion of other details contained in ABNT norms or international standards.

The Technical Documentation will ensure that all ESS technical data and specifications, as built, are available, in a complete and organized manner, allowing easy access by the **CONTRACTING PARTY**, an inspector or maintenance personnel.

The **CONTRACTOR** shall provide five printed copies and five digital copies of the DT. Complete, single multi-line electrical diagrams, as built, shall be printed in a format suitable for viewing (A1 or A0).

5.2.1 Basic ESS information

- Name of the ESS owner;
- ESS location (address and geographic coordinates);
- Brief description of the composition of the ESS and its subsystems;
- Capacity and nominal power of the ESS, including subsystems (kWh and kW - kVA);
- Main electrical characteristics (voltages, currents, powers, etc.) of the entire system including subsystems;
- Installation period;
- Inspection period;
- Commissioning testing period;
- Photographic registration of the facilities.

5.2.2 ESS project designer information

The **CONTRACTOR** shall provide at least the following information on all those responsible for the ESS project. If more than one company has project responsibilities, the information must be from all companies, along with a description of the activities carried out in the project.

- Company Name;
- Technical manager;
- Postal address, telephone number and e-mail address;
- Activity (s) carried out in the project.

5.2.3 ESS installer information

The **CONTRACTOR** shall provide at least the following information on all those responsible for the installation of the ESS. If more than one company is responsible for the installation, the information must be from all companies, along with a description of the activities carried out in the project.

- Company Name;
- Technical manager;
- Postal address, telephone number and e-mail address and
- Activity (s) performed at the facility.

5.2.4 Diagrams

Single and multi-line diagrams shall include at least the following information:

- ESS components (ESS and VEU);
- Cable specifications - straight section type and area;
- Type, voltage and current characteristics and location of disconnecting switches;
- Details of Surge Protection Devices (SPD) on DC and AC circuits, including type, location, voltage and current characteristics;
- Specifications of overcurrent protection devices, including type, location, and voltage and current characteristics.

5.2.5 Data sheets and technical manuals

Data sheets and technical manuals should be provided for the following system components:

- Technical manuals and datasheets of battery banks;
- Technical manuals and datasheets of rectifiers/inverters;
- Data sheets of other significant components of the system, such as protective devices and transformers;
- Technical manuals and data sheets of all components of the data acquisition and analysis system;
- Technical manuals and data sheets of all components of the atmospheric discharge protection system and the HVAC system.

5.2.6 Basic Operation and Maintenance Manual

The "Basic Operation and Maintenance Manual" must be written in Portuguese, containing information on the operation and maintenance of the ESS, including at least the following items:

- Warranty certificates for battery banks, rectifiers/inverters, sensors, meters and other ESS equipment, with guarantee start date and warranty period;
- Documents guaranteeing the materials used and guaranteeing the services performed, such as assemblies, installations and others;
- Operational description of the system, including all functionalities and description/navigation of the monitors in the data acquisition and analysis system (DAAS) - HMI.
- Procedures to verify correct functioning of the ESS;
- Procedures to be performed in case of system failure (troubleshooting);
- Emergency shutdown procedures;
- Maintenance and cleaning recommendations.

5.2.7 Safety and Accident Management Manual

The Safety and Accident Management Manual must be written in Portuguese and should contain at least the following items:

- Description of the ESS potential risk situations (gases, fire, explosion, etc.);
- General safety procedures during operation and maintenance;
- Diagrams and explanatory drawings;
- Procedures for the safe operation of the batteries;
- Description of devices used at the cell level for thermal, voltage and current protection, and thermal insulation between cells to prevent heat and flame propagation;
- Procedures to be followed by ESS operators in case of accidents.

5.3 OVERSIGHT

According to NBR 5410/2008 every electrical installation must be checked during assembly, as much as possible, and at the end before being put into service.

The **CONTRACTING PARTY** will monitor the progress of the services performed and the state of the installations performing periodic, scheduled and occasional inspections.

5.3.1 Inspection

The inspection consists of the examination of an electrical installation, in order to verify the correct selection and proper assembly of the electrical equipment. ESS inspections will be carried out following the items described in standard NBR 5410/2008. The main objectives of the inspections are:

- Confirm that the installed materials and equipment confer in number and characteristics with those informed in the Executive Project;
- Determine, as far as possible, whether the installation and all of its equipment are in satisfactory condition for use.

The inspections will be carried out after each completed stage, defined by common agreement between the parties, and must be carried out by an inspector designated by the **CONTRACTING PARTY**, who must be a qualified professional with the knowledge to carry out the inspections. The inspection will be accompanied by a representative of the **CONTRACTOR**.

The **CONTRACTOR** shall make available to the inspector designated by the **CONTRACTING PARTY** the necessary facilities, materials and equipment and shall provide technical assistance for the correct and safe execution of the inspections, at no cost to the **CONTRACTING PARTY**. The final inspection will be done prior to the full power up of the ESS and the commissioning tests.

5.3.2 Inspection report

After the inspection, the inspector shall prepare the Inspection Report, which shall indicate which stage has been completed and which parts of the system have been inspected. The Report must be written presenting the information according to the norm NBR 5410/2008.

The **CONTRACTOR** shall immediately remedy any inconsistencies noted in the Inspection Report and take steps, if any, to prevent such occurrences from recurring. The **CONTRACTING PARTY** shall approve the corrections and authorize the continuation of the work in the mentioned places.

5.4 SCHEDULE

The installation of the storage system will take 180 days to complete. Within this period, the 30-day ESS commissioning period shall be accounted for, which shall be performed by the **CONTRACTOR**. Here is a suggested schedule with the activities and duration required for each stage.

		Week																						
N°	Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	Dimensioning of the electrical grid of battery connections																									
2	Elaboration of electric power design																									
3	Elaboration of the electrical design of the auxiliary network																									
4	Elaboration of materials list																									
5	Start the purchase process																									
7	Supervision and allocation of materials delivered																									
8	Assembly of connection and distribution boards																									
9	Cable routing and their connections																									
10	Commissioning of auxiliary systems to batteries																									
11	Commissioning the battery pack																									
12	Project design As-Built (Batteries)																									

FIGURE 4 - SCHEDULE WITH ACTIVITIES AND TIME REQUIRED FOR EACH STAGE.

5.5 GUARANTEES

5.5.1 Installation Warranty

The **CONTRACTOR** must guarantee that the executed services will not present any defect of labor and/or structure, for a period of 05 (five) years, counted from its final delivery to UFSC, as provided in article 618 and following of Law 10,406 of 10/01/2002 (Civil Code). The termination of the warranty period does not affect or diminish the liability of the **CONTRACTOR** for the damages and losses that it causes.

The **CONTRACTOR** is obliged to guarantee the materials and equipment provided and installed against any manufacturing defect, as well as guarantee the performance of the equipment, for the respective specific terms defined in this **CONTRACT**, as set forth in article 618 and following of Law 10,406 of 10/01/2002 (Civil Code). The termination of the warranty period does not affect or diminish the liability of the **CONTRACTOR** for the damages and losses it may cause.

5.6 COMMISSIONING AND PERFORMANCE ASSESSMENTS

Commissioning consists of a series of tests that must be performed to verify the full operation of the components and the ESS as a whole. The **CONTRACTOR** shall indicate what its commissioning plan is, detailing all the tests it deems necessary for system startup before starting these activities.

Reports must be provided with all data resulting from commissioning tests and performance evaluations conducted in accordance with relevant Brazilian and international standards, which shall be cited in the text and included in the results.

Equipment commissioning services include:

- The following tests on the electrical panels:
  - Circuit continuity test;
  - Insulation resistance test;

- Test operation of circuits;
- Parameterization and adjustment of electronic devices, such as: protection relays, frequency inverters, soft-start switches, multi-meters, transducers, power sources, etc;
- Revision and re-assembly of screws and connectors of all equipment;
- Energization test of the circuits, command, control, protection and supervision.

• Perform the following tests on the power and control cables:

- Test cables continuity;
- Insulation resistance test;
- Applied voltage test.

5.7 POST-COMMISSIONING SERVICES

Post-commissioning services are activities to be carried out by the **CONTRACTOR** in order to monitor the operation and performance of the ESS for 24 months after delivery of the ESS to the **CONTRACTING PARTY**. Post-commissioning activities will be performed during scheduled technical visits.

5.7.1 Scheduled technical visits

The **CONTRACTOR** shall carry out scheduled technical visits, accompanied by technicians indicated by the **CONTRACTING PARTY**, which shall occur after one, six, 12 and 24 months, counted from the conclusion of the commissioning. The scheduled technical visits will be carried out on agreed dates with the **CONTRACTING PARTY** and may last one or two days.

Among the activities to be carried out are: preventive maintenance, operational tests, verification of performance measurements, verification of protection systems, verification of the data acquisition system and updating of the operation and maintenance procedures used by the **CONTRACTING PARTY's** teams.

5.7.2 Technical visit report (TVR)

The **CONTRACTOR** shall prepare a Technical Visit Report (TVR) after each technical visit, containing information on the operation of the ESS, measurement results and occurrence of events or failures and the adopted solutions. The TVR must be approved by the technicians, indicated by the **CONTRACTING PARTY**, who accompanied the technical visit.

The TVR may also contain suggestions for any modifications or improvements that may be used in the operating procedures or in the ESS.

6 WORK SAFETY

The execution of all works and installations, whether mechanical or electrical, must comply with applicable Work Safety standards, such as:

- NR 10 - Security in facilities and services in electricity;
- NR 18 - Conditions and working environment in the construction industry;
- NR 33 - Safety and health in work in confined spaces;
- NR 35 - Work at heights.

For the monitoring of services and installations, the **CONTRACTOR** shall prepare monthly reports detailing the execution of services and installations carried out in the period.

7 ESS SAFETY REQUIREMENTS

Electrical installations present different types of risks, the consequences of which must be foreseen in order to establish and adopt procedures to minimize the effects on man, property and the environment. The energy storage system (ESS), made up of battery banks of Li-ion technology, associates electrical and chemical risks to the ESS, object of this technical specification.

Li-ion batteries usually do not release hazardous, corrosive or flammable substances under normal use. However, because they contain organic electrolyte, they are flammable and susceptible to auto-ignition, which may occur due to internal short circuit caused by physical damage after mechanical impact, internal manufacturing defect, heating (high temperature), overload or very fast charge or discharge processes.

The CONTRACTOR shall submit the certifications, based on international and Brazilian standards and norms, that guarantee the safety of all equipment and, in particular, lithium-ion batteries.

Among the various rules and regulations to which all ESS material must meet, some of the following are mentioned:

- EN 13501-1 - Fire classification of construction products and building elements - Part 1: Classification using test data from reaction to fire tests.
- EN 50272-2 - Safety requirements for secondary batteries and battery installations.
- EN 61010-1 - Safety requirements for electrical equipment for measurement, control and laboratory use.
- UN38.8 - Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria - Lithium metal and lithium ion batteries.

The **CONTRACTOR** shall provide a Safety and Accident Management Manual, written in Portuguese, as part of the Technical Documentation (TD)

8 TRAINING

The **CONTRACTOR** shall provide training to the technical personnel and other professionals indicated by the **CONTRACTING PARTY**, with the purpose of qualifying the participants for operation, local and remote monitoring and basic ESS maintenance. The instructor should be a professional with proven experience in equipment and training in the field of energy storage.

The training will consist of theoretical and practical activities, addressing the various components of the ESS. Will be held before the commissioning and be programmed by common agreement between the **CONTRACTOR** and the **CONTRACTING PARTY**. The commissioning should be accompanied by the training participants, as a programmed practical activity, to enable the **CONTRACTING PARTY's** technicians to verify and measure.

Participants will accompany the training with the help of an ESS Training Manual, prepared by the **CONTRACTOR** in Portuguese, and delivered in digital and printed format, and may contain material data sheets in English.

The training will last at least 40 hours, given in five working days, over a week, based on the standard 40-hour week with eight hours of work per day. The **CONTRACTOR** shall submit, for approval of the **CONTRACTING PARTY**, the objectives, manual, detailed program and suggested schedule for conducting the training.

The subjects to be covered in the training should contain at least the following items:

- Presentation of the ESS Training Manual;
- Presentation of the Technical Documentation;
- Single-line diagram and ESS plans as built;
- Functions, characteristics and location of all ESS components;
- Identification of ESS components in the installation sites - Individual site security;
- ESS operation;
- Presentation and detailed explanation of the Basic Operation and Maintenance Manual;
- Normal and emergency shutdown procedures of the ESS and/or the inverters;
- Operation and maintenance plan - Regular ESS inspection;
- Process of cleaning the internal and external environments of the ESS;
- Presentation and detailed explanation of the Safety and Accident Management Manual;
- Practical activities in ESS - Solving basic problems in ESS components;
- Configuration and operation of the monitoring system - Operation;
- Procedures for analyzing and downloading stored data, locally and remotely;
- Proper storage of supplied spare parts.

9 ADDITIONAL INFORMATION

The **CONTRACTOR** agrees that it has obtained in advance all information supplementary to this specification and, therefore, will deliver reports within the standards existing and required by UFSC.

In case of doubt in scope, clarification should be requested from UFSC. Any divergent information on the listed documents must be submitted to UFSC in order to be informed formally.

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Prof. Ricardo Rüther

[FUNCIONALIDADES E DESCRITIVOS – ESS]

ESPECIFICAÇÕES TÉCNICAS E FLUXOGRAMAS

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Sumário

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1. SISTEMA DE AGENDAMENTO E LIMITAÇÃO DE POTÊNCIA

O sistema de agendamento é responsável por agendar uma determinada tarefa, com hora e data para início e fim. O agendamento é importante para que o sistema tenha determinados tipos de operação de forma automática e programada, sem que haja interferência externa no momento da realização da tarefa.

Já o sistema de limitação de potência é responsável por controlar a potência de saída/entrada do sistema, em pontos determinados, garantindo assim a funcionalidade desejada. A limitação de potência é crucial para que o sistema injete ou consuma energia da rede de forma automática, além de ser capaz de controlar os níveis de potência reativa ou capacitiva da rede para garantir os serviços ancilares desejados.

Para todas as funcionalidades apresentadas no presente documento, primeiramente o usuário deve entrar no modo “agendamento”, pois todas as funções devem ter hora e data determinada para começar e terminar, garantindo que ao fim da atividade o sistema retorne ao estado de operação padrão.

Além das opções de agendamento são explanados a seguir exemplos de funcionalidades e modo de operação que o sistema deve obedecer de acordo com os comandos do usuário e o limite físico imposto pelo sistema a ser controlado.

2. MEDIDORES DE ENERGIA

Para as operações de agendamento e limitação de potência, o usuário vai escolher em qual medidor ele quer atuar. Somente os medidores de energia da rede e da bateria podem ser controlados. Os medidores são localizados no sistema conforme FIGURA 1.

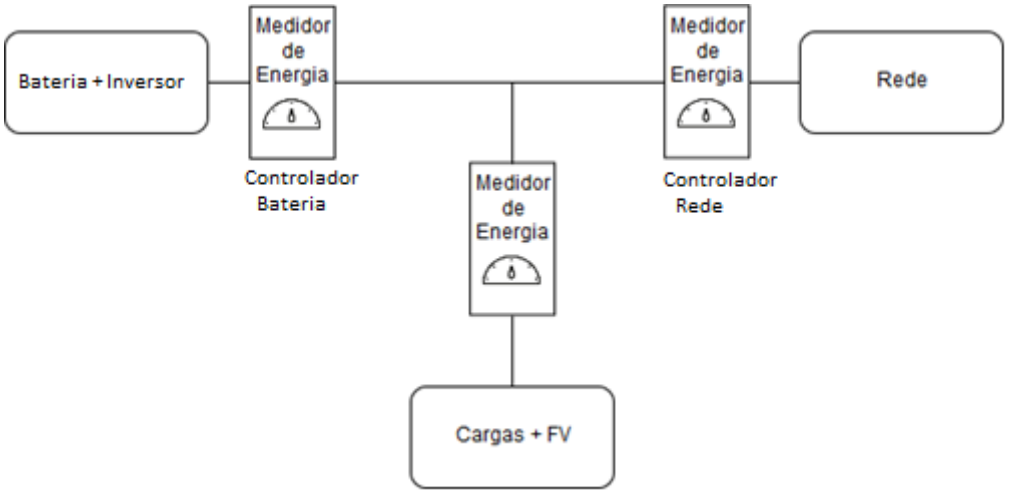


FIGURA 1 – LOCALIZAÇÃO DOS MEDIDORES DE ENERGIA NA REDE.

3. FUNCIONALIDADES

3.1. REQUISITOS DE CONTROLE BATERIA E REDE

Na operação na qual o usuário deseja controlar tanto o fluxo de potência da bateria quanto o fluxo de potência da rede, o principal ponto de atenção é que a lógica desenvolvida respeite os fluxos de potência possíveis fisicamente. Portanto, para cada escolha combinada dos comandos apresentados anteriormente, é necessário que o software faça uma verificação da possibilidade física de implantação do comando, conforme FIGURA 2.

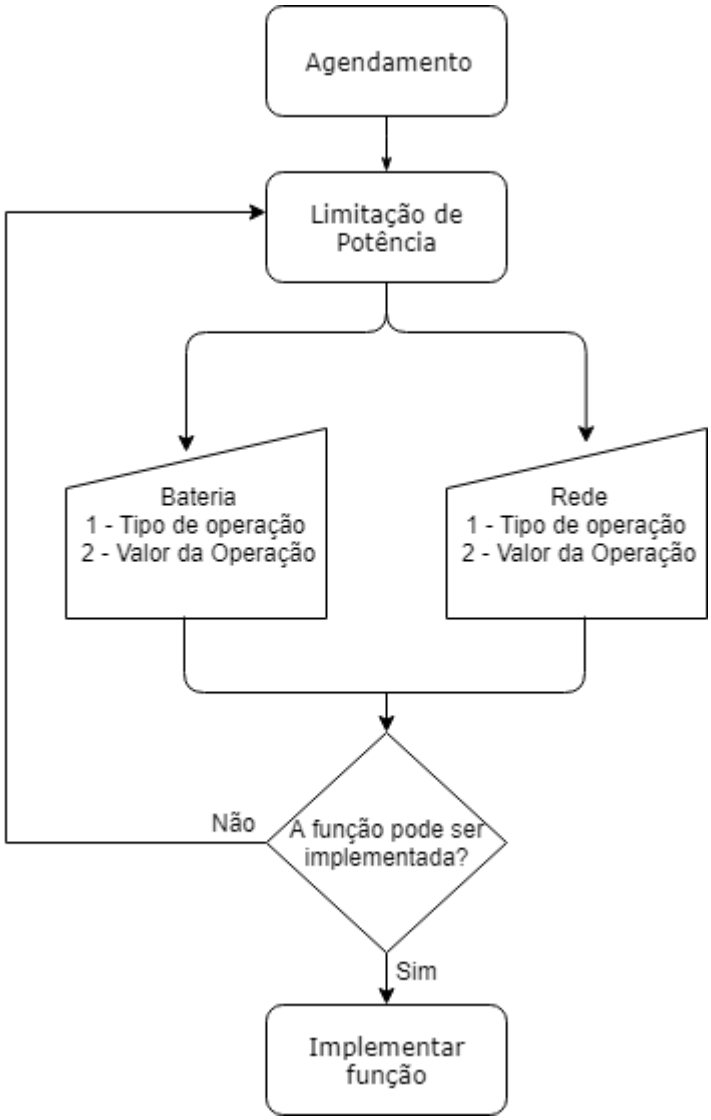


FIGURA 2 – FLUXO DE DECISÃO PARA O CONTROLE DO CONTROLADOR BATERIA E REDE.

3.1.1. CONTROLADOR DE REDE

Caso o usuário escolha por atuar no medidor da rede, ele terá que escolher entre dois modos de operação:

- Injeção de energia na rede;
- Consumo de energia da rede.

Após essa escolha, o usuário definirá qual tipo de controle ele deseja implementar:

- Impor uma potência fixa;
- Impor uma faixa de potência aceitável.

Além de escolher os valores de potência a serem controlados no ponto de medida, o usuário deve escolher o fator de potência e seu respectivo tipo:

- Capacitivo;
- Indutivo.

Esses passos estão resumidos na FIGURA 3.

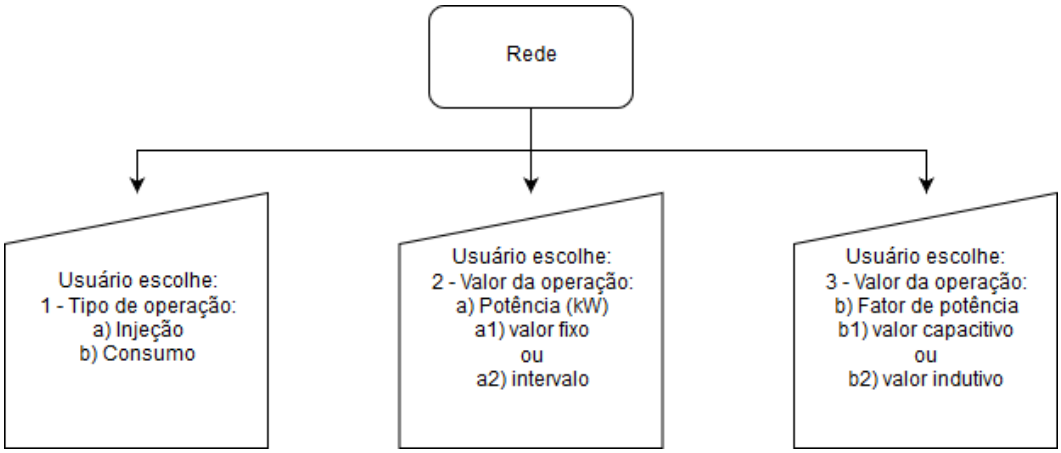


FIGURA 3 – FLUXO DE DECISÃO PARA O CONTROLE DO CONTROLADOR REDE.

Uma vez que o usuário selecionou as opções e valores desejados, o sistema de armazenamento deve garantir as condições especificadas desde que não ultrapasse os valores limites de sua operação, como por exemplo, seu estado de carga.

Exemplo 1: Caso o usuário queira garantir uma injeção de 5 kW para a rede durante uma hora, ele fará o agendamento escolhendo os parâmetros:

Tipo de operação – Injeção;

Valor fixo – 5 kW;

Fator de potência – 1,00.

Dessa forma, o sistema de baterias deve garantir, através da sua carga ou descarga, que os 5 kW serão injetados na rede durante o período especificado no agendamento.

Exemplo 2: Caso o usuário queira garantir um consumo da rede na faixa de potência entre 0 kW e 10 kW, ele fará as seguintes escolhas:

Tipo de Operação – Consumo;

Intervalo – 0 a 10 kW;

Fator de potência – 1,00.

Exemplo 3: Caso o usuário queira garantir que nada seja injetado ou consumido da rede (0 kW no medidor da rede), ele fará as seguintes escolhas:

Tipo de Operação – Consumo ou Injeção;

Fixo – 0 kW;

Fator de potência – 1,00.

3.1.2. CONTROLADOR DA BATERIA

Se o usuário quiser atuar no controlador da bateria, ele terá que escolher entre dois modos de operação:

- Carregar;
- Descarregar.

Após essa escolha, o usuário definirá qual tipo de controle ele deseja implementar:

- Impor uma potência fixa;
- Impor uma faixa de potência aceitável.

Além de escolher os valores de potência a ser controlado no ponto de medida, o usuário deve escolher o fator de potência e seu respectivo tipo:

- Capacitivo;
- Indutivo.

Esses passos estão resumidos na FIGURA 4.

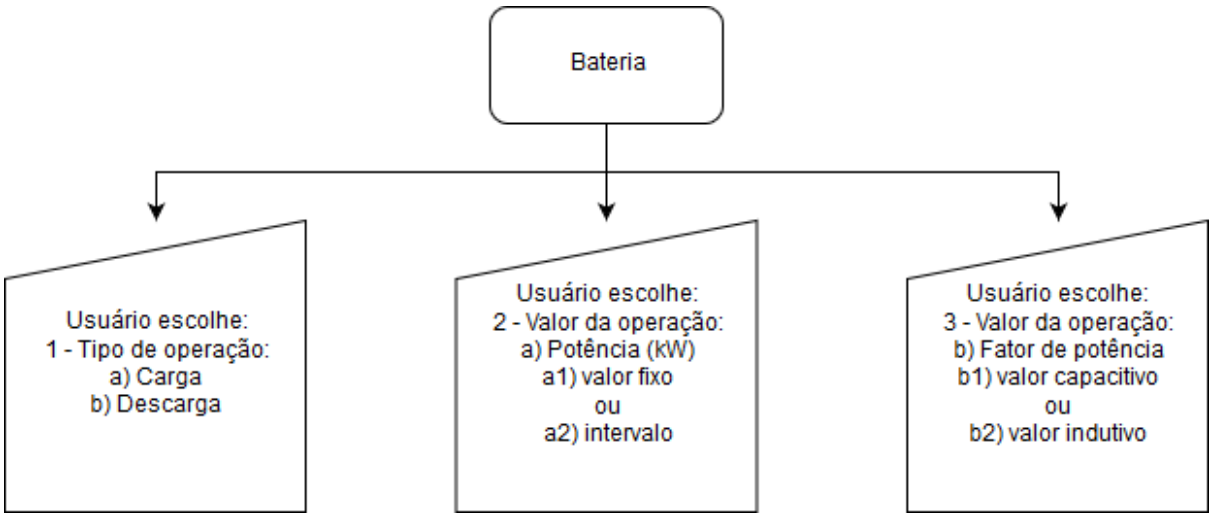


FIGURA 4 – FLUXO DE DECISÃO PARA O CONTROLE DO CONTROLADOR BATERIA.

Uma vez que o usuário selecionou as opções e valores desejados, o sistema de armazenamento deve garantir as condições especificadas desde que não ultrapasse os valores limites de sua operação, como por exemplo, se fator de potência.

Exemplo 1: Caso o usuário queira garantir uma carga da bateria de 5 kW, ele fará o agendamento escolhendo os parâmetros:

Tipo de Operação – Carga;

Valor fixo – 5 kW;

Fator de potência – 1,00.

Dessa forma, o sistema de baterias deve garantir que os 5 kW serão carregados na bateria durante o período especificado no agendamento.

3.2. REQUISITOS DE CONTROLE BATERIA E REDE SIMULTANEAMENTE

Para melhor desempenho de todo o sistema, o usuário deve ser capaz de controlar a bateria e a rede de forma simultânea, conforme *FIGURA 5*.

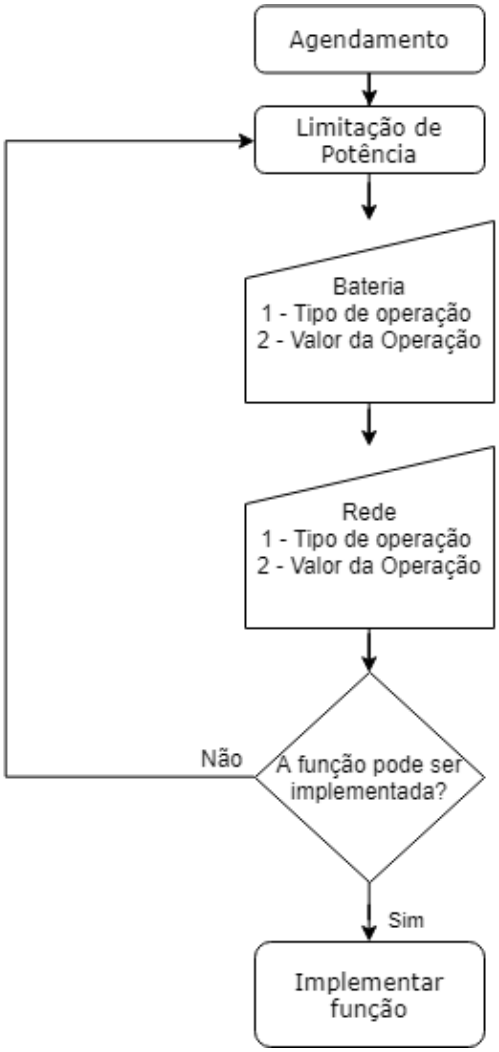


FIGURA 5 – FLUXOGRAMA DO CONTROLE BATERIA E REDE SIMULTANEAMENTE

3.3. MODO ECONOMIA DE ENERGIA

No modo “Economia de Energia” é possível suprir todas as cargas conectadas ao barramento e ainda:

- Recarregar a bateria em caso de energia gerada maior que a carga;
- Selecionar qual a melhor opção para alimentar a carga, no caso da geração fotovoltaica ser inferior a potência consumida: rede ou bateria.

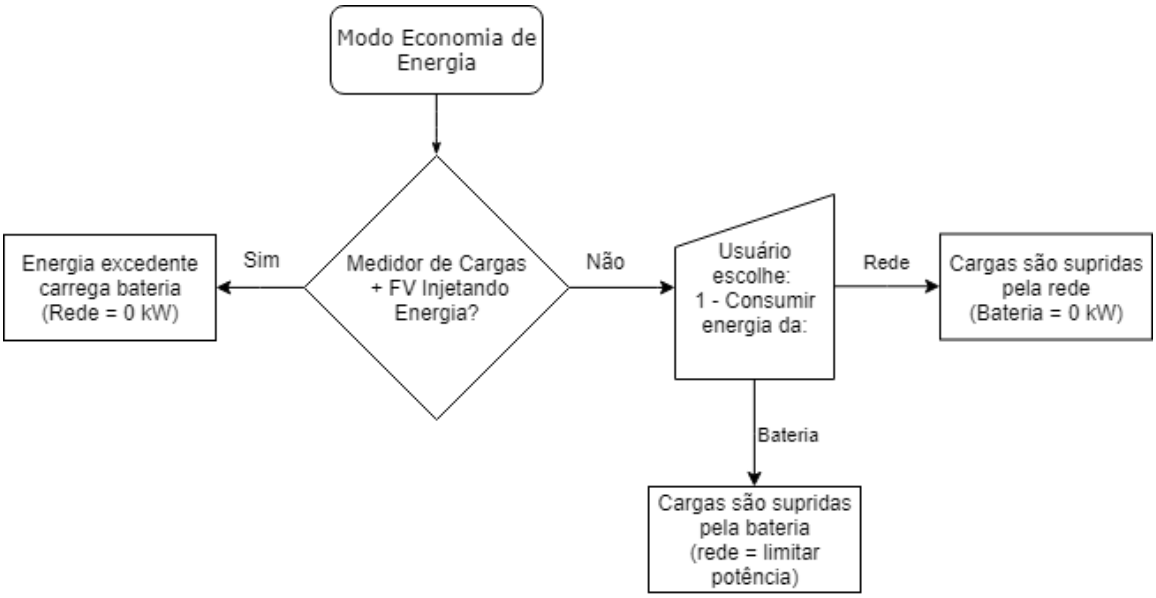


FIGURA 6 – FLUXOGRAMA PARA O MODO ECONOMIA DE ENERGIA

3.4. MODO ILHADO E PRIORIZAÇÃO DE CARGAS

Quando a rede da concessionária falhar, o controlador deve:

- Desligar os todos os sistemas de geração FV;
- Alimentar as cargas com a bateria até que a rede esteja estável novamente;
- Desativar a bateria em caso de carga mínima;
- Controlar o fluxo de carga;
- Controlar o desligamento de cargas prioritárias.

As cargas prioritárias deverão ser separadas em 5 grupos a serem definidos posteriormente.

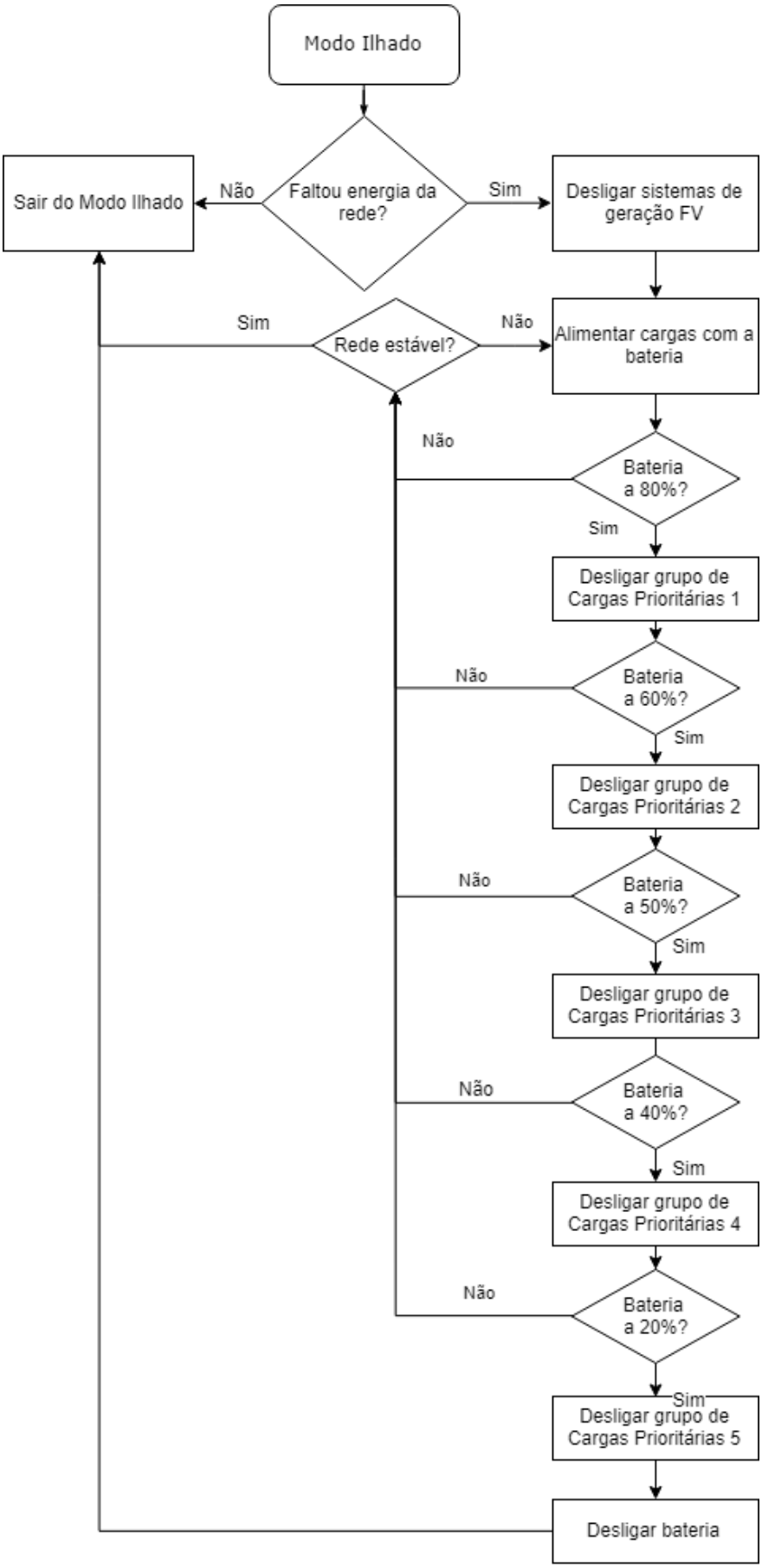


FIGURA 7 – FLUXOGRAMA PARA MODO ILHADO COM PRIORIZAÇÃO DE CARGAS