ATLANTIC POWER energy

ATP Sizing Calculator to Design Energy Accumulators Based on VRLA Batteries

According to the IEEE485-2020 Standard.

SIZING OF AUTONOMY TIMES WITH VRLA BATTERIES

Acorde al Estándar IEEE485-2020.

INTRODUCTION

Battery storage systems are of paramount importance for the successful operation of stationary applications, including but not limited to generating stations, substations, telecommunications, and other stationary applications.

The sizing of autonomy times with VRLA (Valve Regulated Lead-Acid) batteries is a critical aspect in the planning and operation of power backup systems. VRLA batteries are widely used in various applications, from data centers to telecommunications systems and industrial equipment, due to their reliability and efficiency. IEEE 485-2020 standard provides comprehensive guidance for the calculation and sizing of these batteries in stationary applications, ensuring backup systems perform optimally during power outages. This standard is based on commonly accepted methods for defining charging and determining proper battery capacity and is applicable to all VRLA battery installations and sizes.

In this article, **Atlantic Power Energy** will analyze the methodology proposed in the IEEE485-2020 standard for the sizing of autonomy times with VRLA cells or batteries.

Key aspects such as: definition of the DC load, process for the complete sizing of the energy storage system will be reviewed, types of loads defined in the standard will be explained, methodology to identify the different loads that will be supported by the storage system, construction of the duty cycle and work periods according to the load demanded in each one. With this information, it will be possible to calculate the capacity in Ah (ampere hours) of the storage system, and apply the correction factors: temperature, design margin and aging factor.

At the end, **Atlantic Power Energy Autonomy Time Sizing Too**l will be introduced, a tool that has been developed based on the IEEE485-2020 standard, and which allows designers to calculate autonomy times and select the solution with batteries or cells that meet these design criteria.

Keywords: VRLA, IEEE485, IEEE450, IEEE1188, duty cycle, stationary applications.

THE IEEE 485 STANDARD

The IEEE 485-2020 standard is internationally recognized for the accurate sizing of VRLA batteries (Valve-Regulated Lead-Acid batteries).

This standard establishes rigorous methodologies for calculating battery capacity and power needs in various applications, thus ensuring optimal and reliable operation of power backup systems.

The process of sizing batteries according to the IEEE485 standard involves several key steps:

- Critical Load Determination: Identify critical loads that need to be backed up by batteries during a power outage.

- Battery analysis and sizing: Calculate the capacity of the batteries in Ah (Ampere-hours) to maintain the critical loads fed in the absence of grid power throughout the duty cycle.

- Other considerations: Factors such as temperature correction, aging, and design margin, thus ensuring reliable sizing.

Figure 1.
Scope of IEEE485-2020

Its scope includes the definition of types of DC load, the construction of the duty cycle, the methodology for sizing the VRLA lead acid storage system in stationary applications, and guidelines for making a correct selection of the cells or batteries that support the complete duty cycle.

The standard should be worked in conjunction with the IEEE450, IEEE484, IEEE1187, and IEEE1188 standards, which encompass best practices for the design, installation, maintenance, testing, and replacement of vented and sealed VRLA batteries.

Types of Loads

The standard classifies the loads that will be supported by the storage system into continuous loads, non-continuous loads, momentary loads, and random loads.

Continuous Loads:

These are loads that will be energized throughout the duty cycle continuously. Some examples of this type of load are shown in Figure 2.

Figure 2.
Continuous Loads Examples

Non-continuous loads:

Loads that are only present during part of the duty cycle, operating for a certain period of time.

Figure 3.
Non-continuous Loads Examples

Momentary Loads

This type of load can occur once or several times during the duty cycle, but its main characteristic is its short duration, as it does not exceed 1 minute. For their work within the methodology, they are always considered to have a duration of 1 minute, regardless of whether their duration is less.

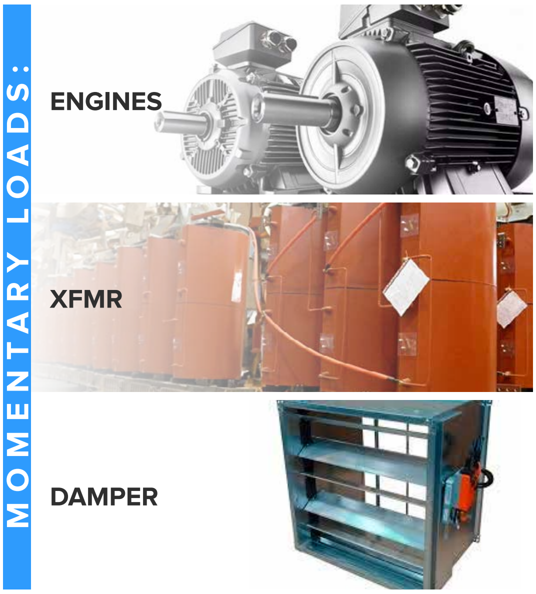

Figure 4.
Examples of Momentary Loads

Random Loads

They are non-continuous or momentary loads, which occur randomly, and their location within the duty cycle must be made contemplating the most critical moment, so as to allow the worst scenario for sizing to be contemplated.

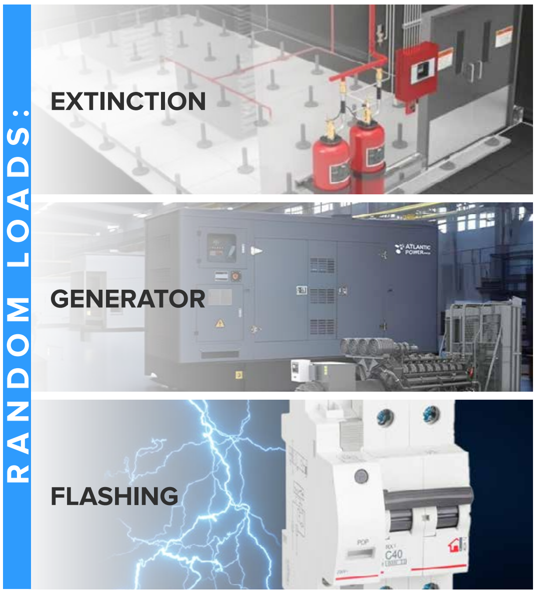

Figure 5.
Examples: Random Loads

Duty Cycle

A sequential organization of the loads that will demand energy from the storage system.

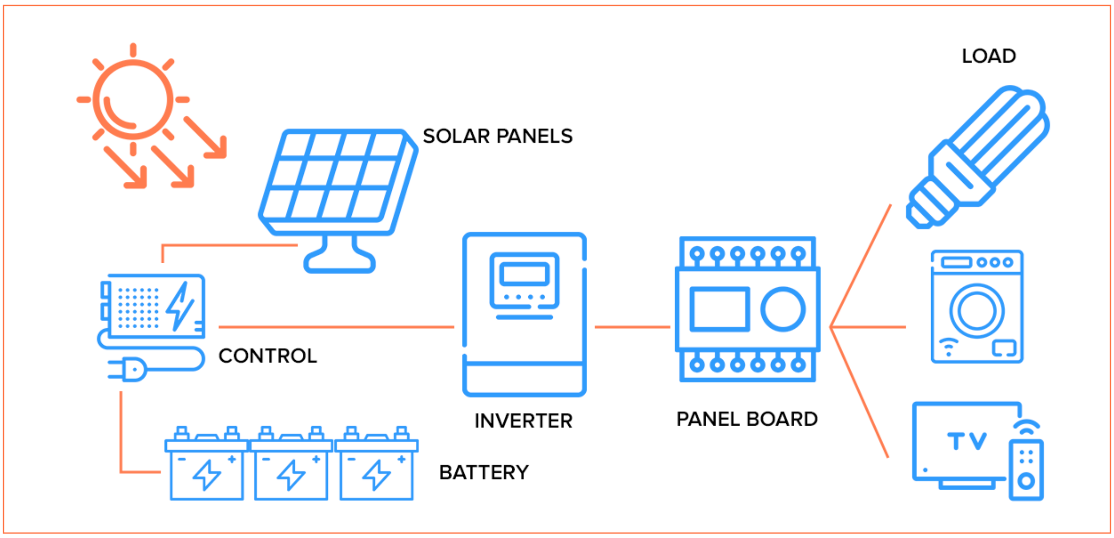

Figure 6.
Example of Solar System Loads

To show the behavior of the duty cycle, the information of each of the loads is tabulated, divided into sections according to the current or power demanded in each period of time. In this way, the actual behavior of the load within the entire duty cycle can be seen graphically and the analysis by sections is facilitated.

Home Solar Plant 120V							
Duration		Continuous Loads			Non-continuous Loads		Random
Time	Min	Fridge	Security & Roter	Total Continuous Loads	Lighting	TV	Compressor
18:00	1	2.5 A	1,3A	3,8 A	1,2 A	0,0 A	8,0 A
19:00	30	2,5 A	1,3A	3,8 A	1,2A	1,3A	0,0 A
20:00	60	2,5 A	1,3A	3,8 A	1,2A	1,3A	0,0 A
21:00	90	2,5 A	1,3A	3,8 A	0,6 A	1,3 A	0,0 A
22:00	120	2,5 A	1,3A	3,8 A	0,0 A	0,0 A	0,0 A
23:00	180	2,5 A	1,3A	3,8 A	0,0 A	0.0 A	0,0 A
00:00	240	2.5 A	1,3A	3,8 A	0,0A	0,0 A	0,0 A
01:00	300	2,5 A	1,3A	3,8 A	0,0A	0,0 A	0,0 A
02:00	360	2,5 A	1,3A	3,8 A	0,0A	0,0 A	0,0 A
03:00	420	2,5 A	1,3A	3,8 A	0,0A	0,0 A	0,0 A
04:00	480	2,5 A	1,3A	3,8 A	0,0 A	0,0 A	0,0 A
05:00	540	2,5 A	1,3A	3,8 A	0,0 A	0,0 A	0,0 A
06:00	600	2,5 A	1,3A	3,8 A	0,0 A	0,0 A	0,0 A

Table 1.
Load Tabulation

In this example, you have a solar system of a home. The contemplated continuous loads are operating throughout the duty cycle (from 18:00 hrs to 06:00hrs next day). Non-continuous loads work within certain periods of time, and random loads work for less than 1 minute, as is the case with the refrigerator compressor contemplated in this case.

Min	Total Continuous Load	Total Non-continuous Load	Total Random Load	
1	3,8A	1,2A	8,0 A	S1
30	3,8A	2,5A	0,0 A	S2
60	3,8A	2,5A	0.0A	S3
90	3,8A	1,9A	0,0 A	S4
120	3,8A	0,0 A	0,0 A	
180	3,8A	0,0 A	0,0 A	
240	3,8A	0,0 A	0,0 A	
300	3,8A	0.0 A	0,0 A	
360	3,8A	0,0 A	0,0 A	
420	3,8A	0,0 A	0,0 A	
480	3,8A	0,0 A	0,0 A	
540	3,8A	0,0 A	0,0 A	
600	3,8A	0,0 A	0,0 A	

Table 2.
Tabulation of Total Loads by Type

Once loads and their behavior over time have been identified and tabulated, the sections are identified (S1-S4) and the duty cycle diagram is generated (Figure 7).

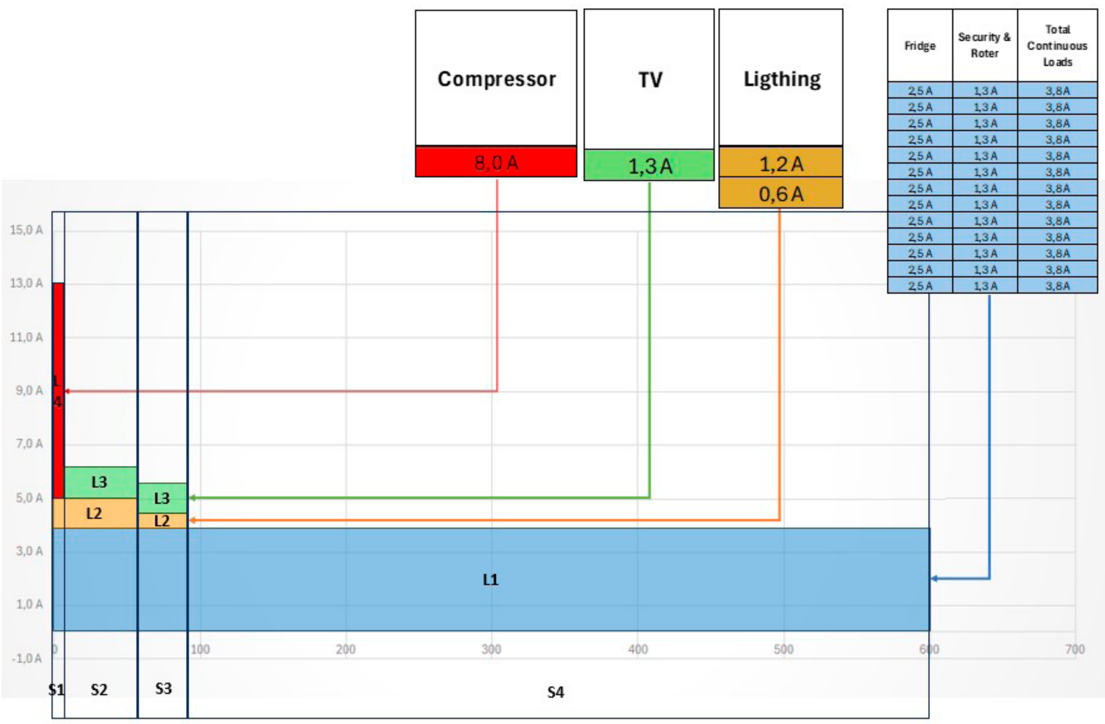

Figure 7.
Duty Cycle Diagram for Example

BATTERY SYSTEM SIZING

The battery system to be dimensioned must be able to withstand all the combined loads of the diagrammed duty cycle. To achieve this analysis, each of the sections of the duty cycle must be analyzed.

Using the following equation, an iterative process is performed that encompasses all sections of the duty cycle, resulting in the uncorrected Ah battery capacity for each section:

$$F = \max_{1 \le S \le N} F_S = \max_{1 \le S \le N} \sum_{P=1}^{P=S} \frac{A_P - A_{(P-1)}}{C_t} \quad (1)$$

Where:

- ***F*** is the size of the battery in Ah, without correction.
- ***S*** is the section of the duty cycle that is being analyzed.
- ***N*** is the number of periods in the duty cycle.
- ***P*** is the period being analyzed.
- ***Ap*** are the amps required for period P.
- ***t*** is the time in minutes from the beginning of period P to the end of section S.
- ***Ct*** is the nominal capacity factor of the cell or battery, at the discharge rate t, @ 25 °C (77 °F), up to a defined minimum voltage.

The sections are analyzed in order according to what was identified in the duty cycle diagram, and the battery capacity is calculated using (1).

If the current of the period P +1 is greater than the current of the period P, then the section S = P +1 requires a cell larger than the section S = P. Consequently, the calculations in the S = P section can be omitted.

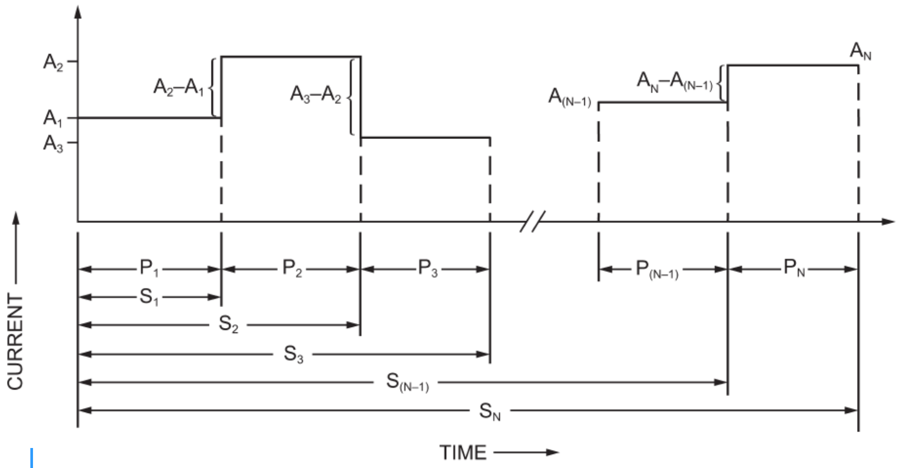

Figure 8.

Generalized Duty Cycle Diagram according to IEEE485-2020

From IEEE 485-2020 Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

IEEE Std 485-2020
IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

Project: Nombre del Proyecto   Date: 20/04/2024   Page:

Lowest Expected Electrolyte Temp: 65 °F   Minimum Cell Voltage: 1,75   Cell Mfg: ATP   Cell Type: GP AGM   Sized By: ATP

(1) Period	(2) Load (amperes)	(3) Change in Load (amperes)	(4) Duration of Period (minutes)	(5) Time to End of Section (minutes)	(6) Capacity at T Min Rate (6A) Amps / Pos (R_T) or (6B) K Factor (K_T)	(7) Required Section Size (3) ÷ (6A) = Positive Plates or (3) × (6B) = Rated Amp Hrs — Pos Values	Neg Values	
Section 1 - First Period Only - If A2 is greater than A1, go to section 2.								
1	A1= 13	A1–0= 13	M1= 1	T=M1= 1			***	S1
					Sec 1 Total		***	
Section 2 - First Two Periods Only - If A3 is greater than A2, go to section 3.								
1	A1=	A1–0=	M1=	T=M1+M2=				S2
2	A2=	A2–A1=	M2=	T=M2=				
					Sec 2 Sub Tot			
					Total		***	
Section 3 - First Three Periods Only - If A4 is greater than A3, go to section 4.								
1	A1=	A1–0=	M1=	T=M1+M2+M3=				
2	A2=	A2–A1=	M2=	T=M2+M3=				S3
3	A3=	A3–A2=	M3=	T=M3=				
					Sec 3 Sub Tot			
					Total		***	
Section 4 - First Four Periods Only - If A5 is greater than A4, go to section 5.								
1	A1=	A1–0=	M1=	T=M1+. . . M4=				
2	A2=	A2–A1=	M2=	T=M2+M3+M4=				
3	A3=	A3–A2=	M3=	T=M3+M4=				S4
4	A4=	A4–A3=	M4=	T=M4=				
					Sec 4 Sub Tot			
					Total		***	

Figure 9.

Template IEEE485-2020 for Sectional Capacity Calculation

To determine the most critical moment, this part of the calculation is done without considering random loads. Then, the section of the duty cycle that defines the capacity of the battery is identified and the capacity derived from the calculation of the random sections is added.

Section 7 - First Seven Periods Only - If A8 is greater than A7, go to section 8.							
1	A1=	A1–0=	M1=	T=M1+. . . M7=			
2	A2=	A2–A1=	M2=	T=M1+. . . M7=			
3	A3=	A3–A2=	M3=	T=M1+. . . M7=			
4	A4=	A4–A3=	M4=	T=M1+. . . M7=			
5	A5=	A5–A4=	M5=	T=M5+M6+M7=			
6	A6=	A6–A5=	M6=	T=M6+M7=			
7	A7=	A7–A6=	M7=	T=M7=			
					Sec Sub Tot		
					7 Total		***
Random Equipment Load Only (if needed)							
R	AR= 100	AR–0= 100	MR= 1	T=MR= 1	0.77	77.0	***
Maximum Section Size (8) 573.8		+ Random Section Size (9) 77.0		= Uncorrected Size – (US) (10) 650.8			

Figure 10.
Total Capacity in Ah without correction according to IEEE485-2020

CORRECTION FACTORS

With the sizing of the capacity of the storage system including random loads, it is necessary to make corrections for factors of temperature, design margin and aging of the batteries.

Temperature Correction

The capacity of the batteries is affected by the operating temperature. VRLA batteries specify their rated capacity for a specific temperature (typically 25°C / 77°F). When the temperature decreases, its capacity decreases and its shelf-life increases. When the temperature rises, its Ah capacity increases, but its lifespan decreases. Each manufacturer has its own curves that show the behavior of this feature.

To have a dimensioning according to the operating temperature, the temperature correction must be included, multiplying the nominal capacity value obtained, by the corresponding correction factor, according to Table 3.

Electrolyte Temperature (°C)	Electrolyte Temperature (°F)	Temperature Correction Factor	Electrolyte Temperature (°C)	Electrolyte Temperature (°F)	Temperature Correction Factor
4.4	40	1.300	26.1	79	0.987
7.2	45	1.250	26.7	80	0.980
10.0	50	1.190	27.2	81	0.976
12.8	55	1.150	27.8	82	0.972
15.6	60	1.110	28.3	83	0.968
18.3	65	1.080	28.9	84	0.964
18.9	66	1.072	29.4	85	0.960
19.4	67	1.064	30.0	86	0.956
20.0	68	1.056	30.6	87	0.952
20.6	69	1.048	31.1	88	0.948
21.1	70	1.040	31.6	89	0.944
21.7	71	1.034	32.2	90	0.940
22.2	72	1.029	35.0	95	0.930
22.8	73	1.023	37.8	100	0.910
23.4	74	1.017	40.6	105	0.890
23.9	75	1.011	43.3	110	0.880
24.5	76	1.006	46.1	115	0.870
25.0	77	1.000	48.9	120	0.860
25.6	78	0.994			

Table 3.
Note: This table is based on 1,215 lead-acid rated specific gravity cells rated at 25°C (77°F). For cells with other specific gravities or nominal temperatures, consult the manufacturer.

From IEEE 485-2020 Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

Design Margin

It is advisable to consider a margin of safety in the sizing process when there are variables that cannot be considered within the nominal calculation. The variability of loads is one of the main reasons for considering this margin, in cases where the load may vary after the initial sizing.

In this case, the designer's expertise is paramount, as he or she must have the ability to determine whether to apply this correction factor and what value it should add. This correction factor can range from 5% to a maximum of 20%.

Aging Factor

The IEEE450 and IEEE1188 standards define that the useful life of a battery comes to an end when its capacity is reduced to 80% of its nominal capacity. This reduction in capacity can be caused by the operating time, the number of discharge cycles, or by other variables associated with its operation or environment, such as the working temperature. At this point, it is advisable to perform the storage system replacement.

To ensure that the system will be able to withstand the full load throughout the duty cycle, even if its capacity reaches 80%, it is necessary to make a correction of its capacity in the sizing process. This factor corresponds to multiplying the uncorrected capacity by 1.25 (125%), thus ensuring that the calculated load is sustained at the end of its useful life.

ATLANTIC POWER ENERGY RUNTIME SIZING TOOL

At **Atlantic Power Energy,** our mission is to provide innovative solutions and advanced tools that enable our distributors to stand out in the marketplace and provide exceptional service to their customers. That's why we've developed **VRLA Battery Runtime Sizing Tool according on the 2020 IEEE485 standard.**

Our tool simplifies this complex process by providing an easy-to-use online platform.

To start using this tool and access its benefits, simply follow these steps:

1. Register on the platform by visiting https://sizing.atlanticpowerenergy.com/register.

2. It is necessary to use a business email, the platform does not support personal emails.

3. By mail you will receive a confirmation about the activation count.

4. Log in to https://sizing.atlanticpowerenergy.com/login with your business email and the password you assigned.

5. If you forgot your password, click "Forgot your password" and follow the process to reset it.

Once inside our Sixing Tool, you will be able to:

- VRLA batteries are designed for stationary applications such as Uninterruptible Power Supply Systems, Solar Systems, DC Power Supplies for Inverters in Telecommunications Systems and much more.

- Perform calculations by power or current method.

- Run corrections for temperature, aging factor, and design margin.

- Select any battery from Atlantic Power Energy's portfolio, obtaining a very wide range of configurations: types of batteries (AGM, Gel, General Purpose, High Rate, Front Terminal).

- Select the number of batteries and strings to make custom configurations.

- Graphically view the different configurations, as well as the oversizing of each of the available options, allowing you to choose the most suitable one.

- Generate reports with the calculation memory according to the parameters and type of batteries selected, which will serve as a support to technically support any solution.

- Download the technical data sheets of the batteries, where you can obtain all the information about them, as well as their charging and discharging curves, etc.

We are confident that this tool will not only make the battery sizing process easier for them, but also improve the accuracy and efficiency of their projects. If you have any questions or need assistance during the process of registering or using the platform, please do not hesitate to contact our technical support team by clicking on this link.

We hope they will take full advantage of this new tool and help them differentiate themselves in the market and provide reliable energy solutions to their customers.

ABOUT ATLANTIC POWER

With more than 15 years of experience in the sector, **Atlantic Power** stands out as a leading manufacturer of UPS, precision air conditioners, VRLA and Lithium-ion batteries, generators, switches and reclosers for MV, data center infrastructure and asset monitoring. With an extensive track record of delivering reliable and efficient energy solutions throughout North, Central and South America, as well as the Caribbean, our company prides itself on offering not only high-quality and efficient products, but also exceptional technical service that ensures customer satisfaction at all stages of the process, from initial consultation to installation and ongoing maintenance.

Our equipment is renowned for its high reliability and low failure rate, making it the preferred choice for a wide range of critical applications in various industries. At Atlantic Power, we are committed to providing state-of-the-art energy solutions that exceed our customers' expectations and ensure the continuity of their operations at all times.

Wecontinue to innovate to provide our customers with state-of-the-art products with the best standards of safety, quality and efficiency.

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