Centauri Energy Server
Technology and Product Overview

The Centauri Energy Server is a stand-alone, modular, plug-and-play, hardware and software platform that aggregates energy generated from multiple input sources, regulates and controls distribution of the energy to load and storage during generation, and then from storage to load when there is no renewable generation. The Server independently handles peak load without grid or gen set support.

A comparison of selected features of the Centauri Energy Server with smart inverters / PCS:

Feature	Centauri Energy Server	Smart Inverter / PCS
Pure Sine Wave Resolution	High resolution 1024 bit high speed switching	Standard resolution 16 bit
AC Overload (Torque Load) Setting	1000% for 2s	~150% - 250% for 15s
	999% to 200% for next 8s	
	200% for next 180s	
DC - AC System Efficiency	96.7% on reactive load & 99.1% on resistive load	~80%
Solar Charge Controller / Wind Charge Controller	Standard MPPT + proprietary charge algorithm increases battery capacity of select batteries by 40% and enables elimination of DOD limitation	Standard MPPT only
Battery Balancing	Continually monitors and balances batteries at the individual cell level for 2V/12V Lead Acid/AGM/Gel/Flooded/Li Ion/Supercap batteries - which increases battery life	Not available
Multiple Input Generation Sources with Blended Output	PV solar, wind, diesel generator, grid, geothermal, battery, or any other AC or DC source can be concurrently connected as input and blended in a user determined percentage and delivered as regulated output	Not available
Multiple Input Source Switching	Available	Not available
Switching Time between Input Sources	0.00ms	Not Available
Switching Time to Bypass Mode	4ms	
Power Factor Correction on Load	Actively corrects power factor on load to 1	Not Available
Harmonics Filtering	Actively filters harmonics generated by reactive loads	Not Available
Monitoring	Built-in Standard. Unique user programmable data logging interval between 100ms to 10s, and data storage of all logging events on the Server's hard drive	Not available - added as accessory
Bypass Mode	Available	Not Available
Static Bypass	4ms switching time	
Auto Bypass	Overload or short circuit	
Manual Bypass	Available	
Auto Gen Start	Available	Not available

1. Introduction

Renewable generation is being fed into the grid network (utility scale or rooftop) but the grid network is not designed to accept an intermittent, non-dispatchable, low capacity factor, bi-directional (in the case of rooftop) generation source. Therefore, there are significant technical challenges arising in the grid network as renewable penetration increases, and importantly, significant commercial challenges arising as the renewable industry tries to balance its needs with that of the network operators.

The reason that renewable generation is only available to the grid is because of the limitation in control electronics technology which is only capable of delivering grid-tied solutions.

The Centauri Energy Sever is a proprietary control electronics platform (hardware + software) available now, that provides network operators with a technically and commercially deployable solution to integrate high penetration of renewables.

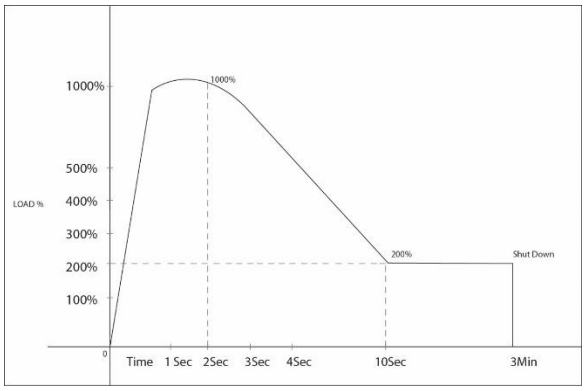
The Centauri Energy Server has been designed to allow network operators to offer customer-centric and customer sited renewable based solutions that work technically by providing relief to the grid and commercially by eliminating the need for net metering programs. It is available in configurations from kW to MW.

The following sections describe the unique features, applications and technology of the Centauri Energy Server.

2. Unique Features

2.1. Torque Load Handling (1000%)

The Server's power module (inverter) generates a sine wave curve at a very high resolution of 1024 bits per quarter cycle. This feature enables the Server to handle torque loads (surge currents generated when devices such as motors and air-conditioners start) of up to 1000%, therefore, handling the peak loads of the load without the support of the grid.



Torque Load Handling Curve

2.2. Efficiency

The Server operates at high input DC voltage (384VDC – 1200VDC depending on Server model). This coupled with the high resolution sine wave results in high DC to AC efficiency. The Server's power module DC to AC efficiency is 96.7% for reactive loads and 99.1% for resistive loads.

2.3. Energy Blending from Multiple Sources

The Server's accepts multiple input generation sources concurrently and delivers regulated, blended output in a user determined percentage. The generation inputs that can simultaneously be connected to the Server include PV solar, wind turbines, diesel generator(s), grid, geothermal, batteries, or any other AC or DC source. This enables the network operator to guarantee 24-hour power to its customers by connecting the grid to the Server to be used in case of weather events (reduced PV generation) or high use days (customer may exceed its average consumption).

2.4. Input Source Switching

The Server's unique chassis architecture and design enables switching between input sources with interim support from the battery. This allows the inverter to always be energized even while input sources are switching, making the source switching seamless from the load's perspective. This feature controls intermittency of renewable generation inputs, thereby delivering stable and regulated power output.

2.5. Power Factor Control

The Server actively corrects power factor of the *load* to 1, using a single, large capacitor / inductor as a digitally variable capacitor / inductor.

2.6. Harmonics Filtering

The Server's harmonics filter connected on the output power line actively analyses and changes RLC values to filter out resonated harmonics frequencies generated on the line through variable reactive loads.

2.7. Monitoring

The Server's monitoring functionality delivers a user programmable data logging interval that can be set between 100ms to 10s, as well as data storage of all logging events on the Server's hard drive. This allows the network operator to be able to monitor each system, predict failures at the individual system level, isolate faults from the network etc. In addition to enabling user programmable logging and in-built data storage, the Server's monitoring has the following functionality:

- It is fully compatible with all known protocols (read / write) like Modbus, Profibus, CAN etc.
- It stores all logging files of all events that occur during the life of the Server which include:
  - PV input metrics (V/A/W/Wh)
  - Battery input / output metrics of every battery cell connected to it (V/A/W/Wh/^{o}C)
  - Wind input metrics (V/A/W/Wh/ms^{-1})
  - Diesel generator input metrics (V/A/W/Wh)
  - Grid input metrics (V/A/W/Wh/VAR)
  - Load metrics (V/A/W/Wh/cos Θ)

2.8. Redundancy of Control

Three different microcontrollers simultaneously control all the components and functions of the Server through a common communication bus. In the event that one microcontroller hangs due to any reason, the watchdog microcontroller seamlessly transfers the control to the redundant microcontroller within the same machine cycle so there is no loss of instruction and the control remains uninterrupted. The third microcontroller always remains as a backup and maintains the storage of different settings and sensors data. Making the Server a robust and resilient control device requiring minimal maintenance and monitoring.

2.9. Stand-alone Platform

The Server is unique in that all hardware components and software based functionalities are delivered in a plug-and-play, stand-alone platform. This results in efficient and seamless and fast communication between all components, maximizing energy efficiency across operations, reducing paths to failure in installation, eliminating dependency on external components and delivering the fastest go-to-generation time in the industry.

2.10. Modular Architecture

The Server architecture is modular, chassis based. This enables the Server's capacity (kW) and functionalities (solar charge controller, wind charge controller, battery controller, grid controller, generator controller etc.) to be added / and or increased as user requirements evolve. This provides a platform with the ultimate flexibility in the industry. The Server chassis has "hot swappable" functionality, which means that modules can be changed without shutting down the system.

2.11. Bypass

The Server is embedded with static, manual and auto bypass capabilities to provide maximum safety at installed site.

The static bypass switches the load to a pre-defined energy source statically by the user. Switching time is 4ms with PLL (Phase Locked Loop) synchronization.

The manual bypass is an electromechanical switch connected on the terminal post of the Server which is manually operated by the user. This manual bypass can be used for maintenance. Once the manual bypass is engaged the power is bypassed from the terminal posts and maintenance can be done anywhere inside the system.

In case of an overload or short circuit on the output load the Server's auto bypass function automatically bypasses the load to the grid through the static bypass switch. In case the grid is not available or overload / short circuit is greater than 200% of the Sever capacity, the internal safeties shutdown the Server.

2.12. Battery Balancing

The Server actively monitors and balances the batteries at the individual cell level thereby protecting connected batteries from damage due to overcharging. This is available for 2V / 12V lead acid / AGM / gel / flooded batteries, Lithium Ion cells and Supercap based storage. This is a very critical feature in ensuring connected storage operates at maximum efficiency and safety to deliver the longest cycle life.

2.13. Solar and Wind Module

In addition to standard MPPT function, the solar and wind modules regulate and maximize usage of electrolyte capacity in the batteries resulting in increasing standard Lead Acid / AGM / Gel available capacity by up to 40%.

2.14. Islanding / Anti-Islanding

The Server seamlessly islands from the grid, and reconnects to the grid, responding directly to the signals from the network operator. The transition, in either direction, is automated and is possible as a result of the Server's architecture and communication protocols.

2.15. Intelligent No-Load Shutdown

In battery supply or solar power supply situations, the system will automatically detect if the load is less than 5% and turn off for 1 minute. This reduces energy loss in the system.

2.16. Automatic Frequency Selection

The inverter automatically detects operational frequency between 50 Hz or 60 Hz.

2.17. Intelligent Communication Interface

The Server supports RS232, USB or RS485, SNMP monitoring interface protocols and can be connected to a PC for monitoring. The PC operating systems supported by the Server include Windows/NT/2000/ME/2003/XP/Vista and Mac IoS. This enables automatic logging of events like grid failure, overload, low solar, low battery, overcharge, battery imbalance etc., on a PC.

2.18. Auto generator start

The Server's generator module interfaces with most commonly available generator protocols to auto start and stop generator operation.

2.19. Balance of system

The Server has the following in-built in standard configuration:

- Lightning arrestor
- Static charge blocker
- Circuit breakers
- Fuses and safeties
- Connection busbar
- Low frequency isolation transformer

2.20. Safety

All necessary safeties are in-built in the Server, including over-charge protection, over–discharge protection, load short circuit protection, overload protection, and unique PV anti–polarity connected protection.

3. Operational Functionality

The section below describes the unique operational functionality of the Server and highlights the features that enable the Server to be deployed with storage and 100% renewable generation input to deliver power, 24-hours a day, in a stable, safe, resilient and economical manner.

3.1. Input Sources

The Server accepts the following input sources, delivering sequential or blended power:

- Renewable only (PV solar, wind, biomass, geothermal – concurrently or individually).
- Renewable (primary source) + grid (as a backup source).
- Renewable (primary source) + grid + genset (as backup sources).

3.2. Battery Storage

The Server accepts the following types of batteries:

- Lead Acid
- Lithium Ion
- Supercap
- Gel
- Flooded

3.3. Battery Charging directly from Renewable Generation

- The Server accepts generation input that is 5x its rated power.
- With proper weather, this allows the batteries to be fully charged during sun-hours directly from renewable sources. This is a very powerful and unique feature.
- In case of availability of wind with PV solar, or other renewable sources, battery charging is optimized amongst the various sources.
- MPPT / proprietary charging feature of the Server enhances battery electrolyte utilization which optimizes the limitation of depth-of-discharge (in battery chemistries where this is applicable).

3.4. System Stability

Frequency and voltage control, which is a significant challenge in independent deployments, is easily handled by the Server as follows:

3.4.1. In a typical deployment, the renewable input is sized to meet the daily 24-hour energy consumption of the load (this is possible due to the Server's ability to accept input that is 5x its rated capacity).

3.4.2. During generation hours, the load is being supplied directly from generation and excess generation (due to 5x sizing) is concurrently charging the storage.

3.4.3. The Server has a 0.00ms switching time between input sources, ensuring that a rapid response energy source is always available to the load to handle short-term intermittent generation events. (In case of longer deviations in generation such as unpredictable weather events, the Server's grid module or generator module start and control capabilities ensures system stability).

3.4.4. Finally, after generation hours, the load is supplied directly from the battery source. Which is a stable source of power.

3.5. Voltage and Frequency Referencing

To maintain a reliable reference for voltage and frequency, the Server relies on the inverter coupled with storage, which operates in voltage and frequency control mode to provide its own reference points.

3.6. Islanding / Anti-Islanding

The Server can island from the grid, and reconnect to the grid, responding directly to the signals from the utility. The transition is seamless, in either direction, and automated. This is a result of the Server's architecture and communication protocols.

3.7. Monitoring and Control

The Server delivers a comprehensive monitoring and control module that allows performance monitoring and fault detection and resolution to be monitored and controlled remotely. The control functionality enables user programmable operational policies.

4. Applications

A Server plus storage solution enables the delivery of 24-hour power based on renewable generation (rooftop solar, ground mounted solar, wind, biomass, geothermal), at an end-customer price that is equal to or less than grid based power in selected territories, delivering an acceptable return on investment to the network operator. The Server plus renewable generation plus storage solution handles multiple input sources, manages renewable intermittency, voltage and frequency regulation and control, in one device, in one location. This enables a broad range of applications, which we briefly describe below:

4.1. Demand Growth

A Server based solution enables rapid building of capacity to meet demand growth. New residential communities, industrial parks, commercial centers, educational, military, entertainment sites etc. as well as projects that require extension of the distribution grid, building of new sub-stations and in certain cases, expansion of the transmission grid, can be provided power with Centauri based systems, operating primarily on renewable generation.

Due to the Server's exceptional capability of accepting multiple generation inputs, it provides the network operator significant flexibility in designing the system depending on availability of space and power sources.

4.2. Congestion Relief

For substations that are approaching congestion levels, individual residential, commercial and industrial consumers being serviced by the sub-station can be migrated to Centauri server + renewable + storage based systems at competitive unit ($/kWh) pricing (in select territories). This provides immediate congestion relief to the sub-station, reduces the need for large scale storage at the sub-station, defers technical upgrades, delivers a green solution to consumers with cost savings (in select territories), ensures continued revenue generation for the network operator and importantly, eliminates the need for net metering programs.

4.3. Remote Locations

Remote locations can be provided 24-hour power without having to build a grid infrastructure, with the ability to supply power at a significantly lower cost than fossil fuel generators. Due to the Server's ability to handle torque loads and accept high levels of renewable input, generator input is minimized and restricted to supporting bad weather events only, thereby making remote power cost effective and reliable and clean. The network operator can offer this solution as a service to clients such as mines (network operators traditionally do not offer these services and leave it to EPC's and genset suppliers).

4.4. Critical Assets

Critical assets, such as military bases, hospitals, fire stations, police, rescue, data centers etc. can be secured from emergencies by deploying Server based systems. In an emergency, the Server's islanding functionality will isolate the critical asset and its seamless switching capability will ensure continuity of power from the other generation sources that are available. With the Server's ability to island, seamlessly switch to other input sources, handle torque load, remote monitoring and control capability, the critical assets can continue to function normally (as if there was no emergency) throughout the emergency and as long as alternative input generation sources continue to supply power.

4.5. Return on Investment and Capital Efficiency

The Server's ability to manage renewable intermittency, handle peak load and enhance battery performance, enables the utility to design a cost effective system for its customers, delivering power at competitive pricing (in select territories), reducing the need for power reserves and peaker plants, and ensuring an acceptable return on its capital.

It also enables fast go-to-generation times, which means shorter time to revenue generation.

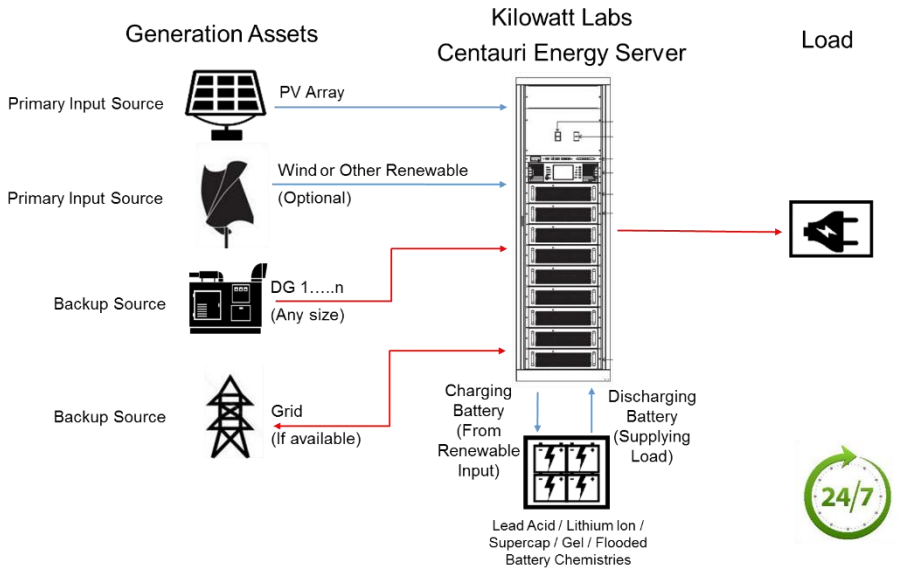
Finally, and importantly, capital allocation is directly related to actual demand growth and not to forecasted demand growth, which results in higher capital efficiency.

4.6. Effective Deployment of DER's

Centauri Server based systems function independently. This is a viable alternative to existing grid-tied systems that cause technical disruption on the grid, and need the support of subsidized programs such as net metering to be financially viable. By deploying renewable + Server + storage based systems, utilities can profitably deploy DER's at the residential, commercial and industrial level, without any technical or financial disruption to the grid or network economics.

5. Application Schematic

The Server can be deployed in any location, for any kind of load profile, with grid or without grid access, with generator or without generator availability, from kW to MW. It does not require any layer of software or hardware to be added, however, if one exists, it can communicate with such hardware or software.



Centauri Energy Server
Technical Specifications - 160 kW Chassis

Chassis	Maximum power	160kW	
	Maximum current	250A	
	Rated input voltage	360V – 440VAC	
	Rated output voltage	380V – 440VAC	
	Battery pack voltage	+240VDC and -240VDC	
	Safeties	Input	MCCB: 800V, 250A, 8kA rupturing capacity Surge and Spike Filtration: Varistor 460VAC ±10%
		Output	MCCB: 800V, 250A, 8kA rupturing capacity Surge and Spike Filtration: Varistor 460VAC ±10%
	Environment	Operating temperature	0~40℃
		Maximum relative humidity	90% (Non-condensing)
		Maximum altitude	Rated power per 100m (1% reduced by rising 100m) Maximum 4000m
	Others	Cooling	Forced ventilation (fan speed varies with load)
		Noise	60 dB (changes with different load and temperature)
		Mean time between failures (MTBF)	200,000 hours
		Protection grade (EN60529)	IP20
		Incoming line way	Lower wiring pattern
		Standards	IEC62040-1-1, EN62109-1:2010, EN62109-2:2011
		Dimensions (W*D*H)	980mm*800mm*1800mm
		Packing (W*D*H)	1050mm*870mm*2030mm
		Weight	~960 kg (all modules inserted)
Inverter Module	Input Voltage – Lower Limit	≥200VDC and ≥-200VDC	
	Input Voltage – Upper Limit	≥290VDC and ≥-290VDC	
	Maximum Power	20kW	
	Maximum Input Current	100A	
	Output Voltage	380VAC – 440VAC (programmable / adjustable)	
	Output voltage accuracy	±1%	
	Transient voltage range	±5%	
	Transient recovery time	20ms	
	Rated frequency	50Hz/60Hz ±1Hz (pre-settable)	
	Frequency tracking range	50Hz/60Hz ±3 Hz	
	Crest factor	3:01	

	Waveform	High resolution pure sine wave 1024 bits per quarter cycle	
	Waveform distortion factor	≤3% (Linear load)	
	Voltage imbalance	±3% (100% unbalanced load)	
	Overload	≥105%-110%	1 hour, then switches to bypass mode
		≥110%-125%	10 mins, then switches to bypass mode
		≥125%-150%	60 secs, then switches to bypass mode
		≥150%	10 secs after which system shuts down. Reduce load to boot
		≥200%	8 secs after which the system shuts down. Reduce load to boot
	Torque load handling	1000%	2 secs
	Short circuit	The system starts limited current operation & immediately shuts down, while the user should confirm boot	
	Maximum efficiency	≥93%	
Bypass	Rated voltage	Three-phase-four-wire +G 380VAC	
	Voltage range	±20%	
	Rated frequency	50Hz/60Hz ±5Hz	
	Maximum current	30A	
PV Module	Maximum voltage range (Voc)	0 V - 750VDC	
	Best working voltage (Vmp)	450 - 550VDC	
	Maximum conversion efficiency	≥98%	
	Float charging voltage	414V ±1%	
	Equal charging pressure	428V ±1%	
	Maximum charging current	400A	
	Maximum working current	400A	
	Maximum power of solar panel (kW)	160 kW (extendable to 500kW)	
	PV input channels	1+1 (Reserved)	
	Proton Exchange / MPPT module	4 +2 (Reserved)	
Grid / AC Rectifier Module	Range of input voltage	Three phase 380V ±20%	
	Rated frequency	50Hz / 60Hz (Background Setting)	
	Frequency range	50Hz / 60Hz ±1Hz	
	Soft start	0-100% 10s	
	Power factor	Max. 0.8	
	Float charging voltage (20℃)	410V ±1%	
	Maximum voltage	415V ±1%	

	Maximum charging current within permitted range of battery capacity	120A	
Battery Management Module (Lead Acid all types, AGM, Gel, Carbon+ and Flooded batteries), Li Ion all types, Sirius all types	Over discharge limit	315VDC	
	Charging current Settings	Factory setting	0.15C10
		User Setting	0.07-0.3C10
	Intelligent battery management	Automatic conversion between even charging and floating charging; Automatic temperature compensation of battery pack (If the system is not connected with the detection line for the battery temperature, the temperature compensation is based on the ambient temperature)	
	Depth of discharge setting for off-peak discharging	330VDC-378VDC (Pre-settable)	
	Battery SOC Balancing	No. of channels	Maximum 20
		Balancing time	1 – 3 hours
		Balancing accuracy	±1%
		Balancing topology	Cell to cell 12V / 2V
Switching Module	Inverter / bypass conversion time	4ms	
	Bypass / inverter conversion time	4ms	
	Inverter / grid conversion time	0ms	
	Grid / inverter conversion time	0ms	
	DG / inverter conversion time	0ms	
	Inverter / DG conversion time	0ms	
	Energy blending	Available / programmable between all input modules (PV, wind, grid, DG)	
Communication and Automation Module	Remote control input	Battery self-check, Server ON/OFF, fault clear, emergency stop	
	Computer monitoring port	RS232, RS485 and SNMP	
	Dry contact output 12VDC/250Vac 1A max	Bypass input fault, rectifier input fault, system fault, system alarm, battery low voltage, output overload, fan fault and generator ON/OFF.	
Diesel Generator Module	Range of input voltage	Three phase 380V ±20%	
	Rated frequency	50Hz / 60Hz (Background Setting)	
	Frequency range	50Hz / 60Hz ±10Hz	
	Soft start	0-100% 25s	
	Power factor	Max. 0.8	
	Float charging voltage (20℃)	410V ±1%	
	Maximum voltage	415V ±1%	

	Maximum charging current within permitted range of battery capacity	120A	
	Maximum efficiency point tracking	Available with load, frequency, power and temperature input	
	Automatic switching	Engine switching and load switching available	
	Protections	Cranking battery charge maintenance	
	Shutdown	Overload	
		Over temperature	
		Over voltage	
		Frequency below and above permitted range	
		Engine airlock prevention	
Wind Module	Rated Power	20kW	
	Wind turbine voltage	280VDC – 440VDC	
	Maximum current	75A	
	Load on voltage	280VDC	
	Maximum voltage	440VDC	
	Wind turbine automatic breaking voltage	500VDC after rectification	
	Recovery time after automatic breaking	10 mins (default adjustable)	
	No load loss	≤45mA	
	Buck & boost function	Available	
Grid-tied module	Maximum DC input	20kW	
	Max DC input Voltage	500VDC	
	Start Voltage	100VDC	
	Rated Voltage	380VDC	
	DC input voltage range	80VDC – 500VDC	
	Max input current	250A	
	MPPT ways	4-way	
	AC output parameters	Rated AC output power	20kW
		Max rated AC output power	22kW
		Max AC output current	100A
		Rated AC output voltage range	220V/230V/240V;180-270V
		Rated grid frequency	50HZ ±5Hz 60HZ ±5Hz

		Power factor	1
		Output harmonics	<3%
		Max efficiency	97%
		European efficiency	96%
		MPPT efficiency	99.9%
	Safety protection devices	DC input reverse polarity protection	Yes
		Input DC impedance monitor	Yes
		Leak current protection	Yes
		AC short circuit protection	Yes
		Mains monitor	Yes
		Output DC component monitor	Yes
		Anti-islanding	Yes
	Environment	Operating temperature	-25℃ – 75℃
		Relative humidity	0% - 95% non-condensable
		IP	IP20
		Night consumption	0.5W