

KILOWATT LABS

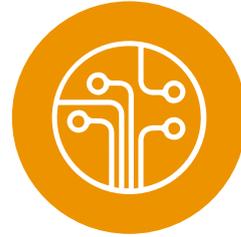
Better Energy

Meeting the energy demands of
today while unlocking the potential
of a sustainable energy future.

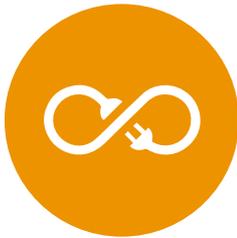
Welcome to a better energy future.



Supercap cell operating temperature range
-30°C to 80°C



No capacity degradation or cycle life
reduction at 100% DOD



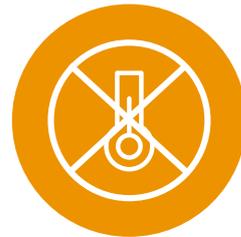
+99% Supercap cell DC-to-DC
roundtrip efficiency



Medium and long duration
discharge capability



Charge/discharge at 1C with no effect on
cycle life or capacity



Safe, with no risk of thermal runaway



10-year warranty



ILLUSTRATIVE USE CASES

SOLAR + STORAGE 

- Plug-and-play replacement of Lead Acid or Li Ion batteries
- Compatible with existing inverters
- Safe with no risk of thermal runaway
- Operating temperature range eliminates need for auxiliary cooling infrastructure
- High delivered efficiency results in low opex so faster payback
- Long cycle life with 10 year warranty

DEMAND CHARGE REDUCTION, TIME-OF-USE SHIFTING 

- Fast charge capability (45 minutes) enables optimized capacity sizing and increase response capability
- Operating temperature range minimizes (and even eliminates) auxiliary cooling cost
- High DC to DC efficiency delivers lowest opex
- High cycle life + high efficiency + low auxiliary opex = lowest cost of ownership and shortest payback
- Works with most inverters

CELL TOWER 

- Compatible with existing rectifier or DC electronics infrastructure
- Operating temperature range minimizes (and even eliminates) auxiliary cooling infrastructure (and therefore cost)
- High cycle life + high efficiency + low auxiliary opex = lowest cost of ownership and shortest payback
- At off-grid locations, reduces generator maintenance costs and increases generator efficiency which lowers diesel
- Plug-and-play replacement for Lead Acid or Li Ion batteries
- High rate of charge capability enables less storage thus saving capex



SIRIUS ADVANTAGE OVER CHEMICAL BATTERIES

ATTRIBUTE	LITHIUM-ION	LEAD ACID	FLOW	SIRIUS	SIRIUS ADVANTAGE
Warranty	10 years with EOL degradation	3 years	-	10 years with no EOL degradation	Lowest opex in the industry
DC round trip efficiency	~90-95%	~70%	65%-75%	95-98%*	Lowest opex in the industry
Depth-of-Discharge (DOD)	80%	50%-60%	100%	100%	Name-plate capacity in usable
Temperature effect	<50°C	<27°C	<50°C	<80°C	Usable in almost any location
Charge current limitation	Sev. limited	Sev. limited	Sev. limited	1C - 2C	Enables fast charging. Very efficient & effective in EV, solar, backup and other applications
Discharge current limitation	2 hours	10-20 hours	2-10 hours	1C - 2C	Single solution for short, medium, and long duration discharging making it the most versatile storage in the industry
Thermal stability	High risk	Minimal	Minimal	No risk	Reduces costs by eliminating the need for auxiliary cooling systems
Energy density	High	Medium	Low	Medium	Effective form factor

	MODEL	SIRIUS 465-12	SIRIUS 1000-12
	Part No.	22892 T	22134 XA
PERFORMANCE SPECIFICATIONS	Nominal voltage	12 VDC	12 VDC
	Maximum charge voltage	13,5 VDC	13,5 VDC
	Discharge cut-off voltage	11 VDC	11 VDC
	Total energy	465 Wh	1000 Wh
	Maximum charge rate	35 A	50 A
	Maximum discharge rate	35 A	50 A
ENVIRONMENTAL SPECIFICATIONS	Cell operating temperature	-30°C to 80°C	-30°C to 80°C
	Operating humidity	Non-condensing	Non-condensing
MECHANICAL SPECIFICATIONS	Dimensions WxDxH	313x183x204 mm	1560x78x117 mm
	Weight	11 kg	23 kg
	Module casing material	Alluminum	Alluminum
	Terminal type	F12	F12
SMART FEATURES	Alarm	Audible alarm in the event of over-voltage, under-voltage, over-temperature, over-current	Audible alarm in the event of over-voltage, under-voltage, over-temperature, over-current
MODULE SERVICE LIFE	Projected supercap-cell cycle life	1 million cycles*	1 million cycles*
	Projected calendar life	45 years	45 years
	Shelf life	10 years	10 years
	Warehousing	Can be stored at any SOC without affecting cycle life	Can be stored at any SOC without affecting cycle life
CRTIFICATIONS		EN55032:2015, EN55024:2010, EN61000-4-2:2009, EN61000 EN61000:2008+A2:2010	EN55032:2015, EN55024:2010, EN61000-4-2:2009, EN61000-43:2006+A1:2008+A2:2010
PRECAUTIONS	Charge/discharge current	Under no circumstances must the charge/discharge current exceed 35 A	Under no circumstances must the charge/discharge current exceed 50 A
	Charging voltage	Under no circumstances must the charging voltage exceed 13,5 VDC for more than 60 seconds	Under no circumstances must the charging voltage exceed 13,5 VDC for more than 60 seconds
	Charge cycle	During charge cycle ensure never to exceed constant voltage of 13,5 VDC and constant current of 35 A	During charge cycle ensure never to exceed constant voltage of 13,5 VDC and constant current of 50 A
	Series connection	All Modules must be at 100% SOC before connecting in series. A maximum of 35 Modules can be connected in series. Please consult your Reseller when connecting the Modules in series. Under no circumstances should more than 35 Modules be connected.	All Modules must be at 100% SOC before connecting in series. A maximum of 8 Modules can be connected in series. Please consult your Reseller when connecting the Modules in series.

*The number of cycles is expected for supercapacitor cells. The life cycle may vary if more than 4 cycles per day are performed.

SIRIUS 3-24	SIRIUS 3,55-48	SIRIUS 7,1-48	SIRIUS 11,4-384
23044 B	22133 VB	21709 UC	23132 Y
24 VDC	48 VDC	48 VDC	384 VDC
27 VDC	54 VDC	54 VDC	432 VDC
22 VDC	44 VDC	44 VDC	352 VDC
3000 Wh	3550 Wh	7100 Wh	11400 Wh
100 A	125 A	296 A	30 A
100 A	125 A	296 A	60 A
-30°C to 80°C	-30°C to 80°C	-30°C to 80°C	-30°C to 80°C
Non-condensing	Non-condensing	Non-condensing	Non-condensing
493x565x201 mm	600x534x200 mm	606x530x345 mm	400x800x1000 mm
50 kg	65 kg	125 kg	230 kg
Alluminum	Alluminum	Alluminum	Alluminum
F12	F12	F12	Isolated screw type terminal
Audible alarm in the event of over-voltage, under-voltage, over-temperature, over-current	Audible alarm in the event of over-voltage, under-voltage, over-temperature, over-current	Audible alarm in the event of over-voltage, under-voltage, over-temperature, over-current	Audible alarm in the event of over-voltage, under-voltage, over-temperature, over-current
1 million cycles*	1 million cycles*	1 million cycles*	1 million cycles*
45 years	45 years	45 years	45 years
10 years	10 years	10 years	10 years
Can be stored at any SOC without affecting cycle life	Can be stored at any SOC without affecting cycle life	Can be stored at any SOC without affecting cycle life	Can be stored at any SOC without affecting cycle life
EN55032:2015, EN55024:2010, EN61000-4-2:2009, EN61000-3:2006+A1:2008+A2:2010	EN55032:2015, EN55024:2010, EN61000-4-2:2009, EN61000-3:2006+A1:2008+A2:2010	EN55032:2015, EN55024:2010, EN61000-4-2:2009, EN61000-3:2006+A1:2008+A2:2010	EN55032:2015, EN55024:2010, EN61000-4-2:2009, EN61000-3:2006+A1:2008+A2:2010
Under no circumstances must the charge/discharge current exceed 100 A	Under no circumstances must the charge/discharge current exceed 125 A	Under no circumstances must the charge/discharge current exceed 296 A	Charge Cycle: Under no circumstances must the charge current exceed 30 A. Discharging Cycle: Under no circumstance must the discharging current exceeds 60 A.
Under no circumstances must the charging voltage exceed 27 VDC for more than 60 seconds	Under no circumstances must the charging voltage exceed 55 VDC for more than 60 seconds	Under no circumstances must the charging voltage exceed 55 VDC for more than 60 seconds	Under no circumstances must the charging voltage exceed 432 VDC for more than 60 seconds
During charge cycle ensure never to exceed constant voltage of 27 VDC and constant current of 100 A	During charge cycle ensure never to exceed constant voltage of 54 VDC and constant current of 125 A	During charge cycle ensure never to exceed constant voltage of 54 VDC and constant current of 296 A	During charge cycle ensure never to exceed constant voltage of 432 VDC and constant current of 30 A
All Modules must be at 100% SOC before connecting in series. A maximum of 16 Modules can be connected in series. Please consult your Reseller when connecting the Modules in series. Under no circumstances should more than 16 Modules be connected.	All Modules must be at 100% SOC before connecting in series. A maximum of 8 Modules can be connected in series. Please consult your Reseller when connecting the Modules in series.	All Modules must be at 100% SOC before connecting in series. A maximum of 8 Modules can be connected in series. Please consult your Reseller when connecting the Modules in series.	No series connection allowed

Can supercapacitor-based storage really replace chemical batteries?

Kilowatt Labs supercapacitor-based energy storage system delivers lower total cost of ownership by replacing chemical batteries

Kilowatt Labs is headquartered in New York City, with production facilities in Dubai producing supercapacitor-based energy storage modules. Supercapacitors, or supercaps for short, are high capacity capacitors, a technology as old as the more familiar lead acid battery. Until now various limitations have prevented the adoption of supercaps for anything other than a small number of power applications, Kilowatt Labs claim to have made a breakthrough which enables the use of supercaps appropriate for energy storage. TowerXchange sat down with Omer Ghani, Managing Director at Kilowatt Labs to discuss what their innovations mean for cell site energy.

TowerXchange: Please introduce your company – what are the origins of Kilowatt Labs?

Omer Ghani, Managing Director, Kilowatt Labs: The idea behind Kilowatt Labs and its technology – were created by Waseem Ashraf Qureshi. He is the inventor behind our technology and co-founder of the company.

He started off with a power management system for minigrids, the Centauri Energy Server and then developed supercap-based storage for cell sites, the Sirius Energy Storage Module. He and I met in Dubai when he had just developed the Centauri Server and needed to organise production and corporatise the business. We invited Chip Seibert, my university roommate to join, and went about raising funds, filing patents and move beyond an idea into a business. That was over three years ago now.

TowerXchange: Please introduce supercapacitors and how they are different to a chemical battery.

Omer Ghani, Managing Director, Kilowatt Labs: Capacitors have been around about as long as batteries. Supercapacitors are just bigger versions of a capacitor. Rather than storing energy as chemical energy, capacitors store it as an electrostatic charge. That's the key difference. The presence of a chemical electrolyte and chemical reaction in a battery, creates their advantages and their limitations, just through the actions of the laws of physics. The chemical electrolyte degrades through cycling and with the effect of heat. They create their own heat too which limits your rate of charging and causes an efficiency loss. You can't charge or discharge quickly because of the limitation of the electro-chemical reaction and that puts a cap on charging speeds, there's a natural barrier.

TowerXchange: Sounds great, but this is an old technology, so why is it not more widely adopted?

Omer Ghani, Managing Director, Kilowatt Labs: Until recently the limitations of supercaps have been more significant than their advantages. The most commonly known limitation of a capacitor is that the energy density is much lower than a battery, so for a given capacity a capacitor's form factor is bigger than a battery. The second most commonly known limitation is that they charge and discharge rapidly. The discharge curve of a battery is flat, whereas the discharge curve of a capacitor is linear, to speak technically. Normally capacitors discharge too rapidly to be useful for energy storage. That rapid discharge makes supercaps great for cranking applications or black starting a power station, or frequency support on the grid. But that is not what is required on a cell site! The third problem is that chemical cells connected in series are easier to balance than supercap cells are. And the fourth problem is that supercaps have a high self-discharge rate. If they are left idle a battery will lose 2-3% of its charge a month. But a supercap normally takes 72 hours to reach about 60% charge. That is a lot of lost energy. Waseem has solved these problems. The result is the Sirius Storage Module. This is not a supercap, it is an energy storage module that uses supercaps to store energy, but the engineering around the supercap is what really adds value. Replacing chemical batteries with our storage module brings major benefits. You can cycle a lot, charge and discharge quickly, there is no heat generation, use 100% of capacity, eliminate the risk of thermal runaway. It eliminates all the problems that come with using batteries.

TowerXchange: How proven is the solution in the field? Please tell us about the performance of your solution in the field – who is using it and what results have been achieved?

Omer Ghani, Managing Director, Kilowatt Labs: We are in commercial operations with commercial supplies through our Resellers in the Philippines, Vietnam, Indonesia, Myanmar, Kenya, India, Southern Africa, Nigeria, Pakistan, Italy, Canada, Australia, New Zealand and UAE. We have supplied more than 5MWh of Sirius Storage Modules to the solar, telco, microgrid, streetlight and forklift sectors. And we have proof of concepts and commercial sites live now with more than 12 telcos worldwide. We start off dealing with the technical guys and explaining how it works and allowing them access to a module to run it and draw measurements from it.

We don't want to pretend this is magic, this is just science, but honestly they fall on the floor when they see it work! They haven't seen anything like it. They are buried under the pain of chemical batteries and our Sirius Storage Module frees them. We have lots of sites running but telcos are slow to move and lithium ion and lead acid are deeply entrenched – nobody got sacked for buying IBM – so there is a slow programme of helping people realise what a great product we have.



**Omer Ghani,
Managing Director, Kilowatt Labs**

TowerXchange: Please compare the TCO for a fairly typical off grid cell site running dual DGs with a similar site where a Kilowatt Labs energy storage solutions has been installed.

Omer Ghani, Managing Director, Kilowatt Labs: We do simulations against cheap lithium ion batteries and our typical paybacks come in at around one to one and a half years, so it is very competitive. Our per kWh cost is not the lowest, but that's a misleading metric. If you want the lowest per kWh cost, I say go buy a lead acid battery, but that won't give you the lowest cost of ownership.



TowerXchange: What's the sweet spot for your solutions in terms of grid availability?

Omer Ghani, Managing Director, Kilowatt Labs: The lowest hanging fruit is sites which have a generator running 24/7. If you add our supercapbased system, you can reduce runtime by 50% at least and produce big diesel savings. Because of the improved cycling and high charge capability you can replace existing batteries with our solution and reduce installed capacity by 30-50% for the same performance. You can cut your runtime by half. This means again that you can be generally running a generator six hours per day instead of ten to twelve with less installed capacity. On sites with uninterrupted grid for most of the year, most telcos would not use anything but lead acid because it is cheap and if you don't cycle it much it will last a long time. That is fine if you are in regions with temperate climates and few spikes in temperature. But, if your battery is installed somewhere that gets hot then most lead acids degrade much more quickly than you would like. In these circumstances we can be competitive because we can offer a long warranty, up to fifteen years. We want to make switching to our storage unit simple as well so it is a plug and play replacement. You don't need to change rectifiers, your cabinet or other electronics. You just unscrew your chemical storage terminals and put Sirius in the same rack and change your rectifier settings. Setup is very simple so even less skilled installation teams in some markets are more than capable.

TowerXchange: Battery theft is a huge problem, which the switch to lithium ion has helped to suppress, what can be done to protect against supercapacitor theft?

Omer Ghani, Managing Director, Kilowatt Labs: We address theft in several ways. First of all it is hard to steal thanks to our anti-theft functionality, which is superior than any other battery. If it is stolen and removed from the rack it switches off. You need two levels of passwords to activate it in the first place. The second aspect is what you can do if you unscrew it and sell all the parts. We make the casing out of aluminium and use a graphene film to hold the charge and neither element is very valuable. The circuit boards are more or less worthless too. Finally, thieves bypass the BMS in lithium ion batteries and draw power directly, which is very dangerous, of course, but it happens. However, if you bypass the electronics and connect directly to the supercaps in our system it just won't work. All the normal issues of supercaps reappear and all the benefits of our storage module are removed.

TowerXchange: What is the typical asset lifecycle of your solutions, how do your solutions extend the lifecycle of other equipment on the site, and how can it be maximised?

Omer Ghani, Managing Director, Kilowatt Labs: The oldest Sirius Storage Module in operation is three years old, so that's the maximum life so far, but it's getting older every day. What we can say is we offer a warranty for ten years and that, unlike a chemical battery, you will get the same energy levels on day 3650 as on day one. That's our warranty. I would like to have a ten year old product to show people but I cannot. My philosophy is the following: here is our product, we have told you it is supercap-based, here is our specification sheet, have your technical guys look it over and verify actual performance against the spec sheet. If we don't meet expectations you can return it and we will refund you. If it works as we say it does then place your purchase order. It is new technology so I understand people's reticence, but we have complete confidence in the product.

TowerXchange: This is a new technology and a new business, what is your expansion plans and how can you convince people you'll be a good counterparty on a ten year warranty?

Omer Ghani, Managing Director, Kilowatt Labs: Let me tell you our history to help your readers understand where we have come from and where we are going. In 2018 we made our first commercial sale. Because we needed to manufacture and Waseem was already in Dubai, we set up a plant there which was 6,000 square feet, that was in the last quarter of 2017. Today we have 100,000 square foot facility with a full R&D lab and a full R&D team. We employ almost 200 people but we are outgrowing it. We are now building a 200,000 square foot facility in Dubai which will be up and running by September 2019. We currently make everything except for the supercaps but when the new facility opens we will be making our own supercaps too. We will be completely vertically integrated to secure supply to our customers. We will have a total production peak capacity of 250MWh a year. We have been raising money and have convinced some real energy insiders to invest in us. NorthWestern Energy, a US utility with a nearly US\$4bn market cap, has invested in us, for example. We are targeting cell sites, but we also manufacture storage for MWh scale, high voltage grid-level applications, microgrids, forklifts, 12V modules, UPS, generator optimisation and replacements for the AA batteries you see in your TV remote. That diversification makes us a great counterparty for cell site energy. Try a module for yourself if you want convincing we have a product good enough to last. We expect supercap-based storage to replace chemical storage over time just because its better – there'll be other supercap-based energy storage companies starting in the future and we hope to replace chemical storage together

ABOUT KILOWATT LABS

Kilowatt Labs creates solutions to the world's complex energy problems. Headquartered in New York, Kilowatt Labs designs and manufactures energy solutions for a range of residential, commercial and industrial uses for the global market. Kilowatt's Sirius Energy Storage, the world's first supercapacitor-based energy storage system, provides safer, more efficient, more effective, longer-life cycle energy storage than any other battery storage product on the market.

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