

OPEN EDGE DISCUSSION

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AGENDA

- Introductions
- Brief Company Overview
- Global Footprint
- Technology Overview
- Open Edge Proposal

COMPANY OVERVIEW

WHAT WE OFFER



**GLOBAL
MANUFACTURING
& DESIGN RESOURCES**

9 countries

4 continents

3K employees

300+ engineers



**VERTICALLY
INTEGRATED**
engineering &
agency approvals



**INNOVATIVE
SOLUTIONS**
for range of markets
& applications



**PROVEN SAFETY
& RELIABILITY**

60 industry
years experience

2K+ programs
launched

1B+ products
safely delivered

MARKETS / APPLICATIONS

BROAD APPLICATION EXPERIENCE

Consumer



- Wearables
- Tablets
- Mobile Phones
- Appliances
- Portable Radios

Data Capture



- Point-of-Sale Terminals
- Barcode Readers
- Printers
- Test & Measurement

Critical Power



- Telecom
- Data Centers
- RAID Storage
- UPS
- Battery Backup

E-Mobility



- E-Bikes
- E-Scooters
- Electric Wheel Chairs

Energy Storage



- Home / Private
- Commercial
- Industrial

Industrial / Low Speed Vehicles



- Forklifts
- Burden Carriers
- Pallet Jacks
- AWP/Scissor Lifts
- Utility/Golf Vehicles
- Ground Support

Medical



- Respiratory Care
- Healthcare Informatics
- Diagnostic Tools
- Cardiac Care
- Surgical Instruments
- Pain Management

Military



- Two-Way Radios
- PDAs & Computers
- Military Vehicle Apps
- UAVs & UGVs
- Soldier Power Source

Power Tools (Indoor/ Outdoor)



- Hand Power Tools
- Lawn & Garden Equip.
- Snow Removal Equip.

BATTERY PACK DESIGN

GROWING HIGHER COMPLEXITY EXPERIENCE



TEST & MEASUREMENT

MEDICAL HEART-PUMP

DATA CENTER

MATERIAL HANDLING

INCREASING POWER

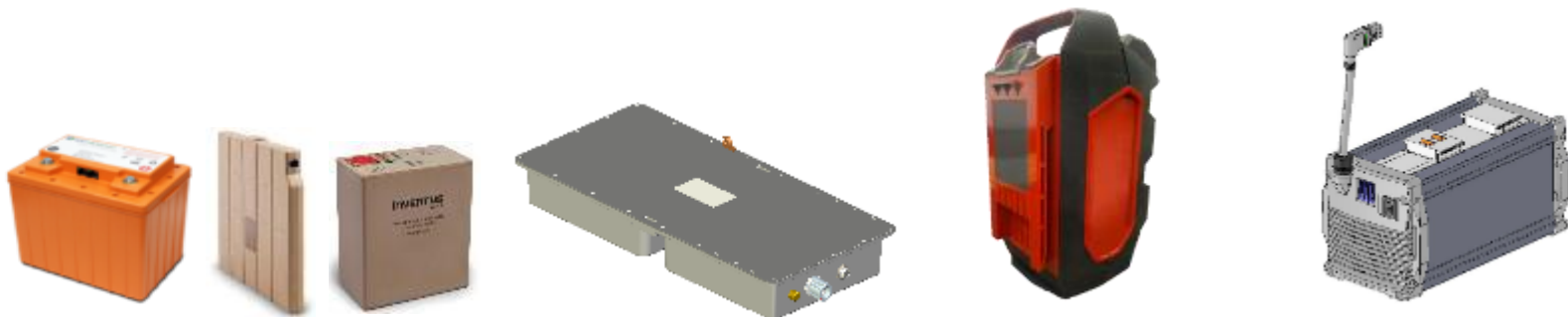
10 W

50 W

1W

2-5kW

12+ kW



MEDICAL
CARTS

MILITARY

ENERGY STORAGE

OUTDOOR POWER
EQUIP

INDUSTRIAL
EQUIPMENT

INCREASING VOLTAGE

24V

30V

48V

60 V

>100 V

TOTAL SYSTEM SOLUTION

BATTERY PACK + CHARGER + POWER SUPPLY

Benefits of a total system design approach:

- Better fit, form & function
 - Smaller, lighter solutions via integration of all 3 components
 - Less redundancy
 - System function integration
- Higher reliability & safety
 - Improved battery life
 - Reduced charge time
 - Better heat management
 - Improved system performance
- Single source solution
 - One partner, not three
 - Reduction of part numbers



GLOBAL FOOTPRINT

ENABLING LOCALIZED PACK INTEGRATION & SUPPLY



GLOBAL PRODUCT DEVELOPMENT

TECHNOLOGY CENTERS, INDEPENDENT TESTING & AGENCY CERTIFICATION

- 2 Technical Centers of Excellence (U.S. & China)
 - ~300 engineers worldwide
 - Electrical, mechanical, & software engineering
- Robust Development Process (Accelerated NPD)
- 100% In-House Design Capability
 - Design capability for complete system (battery, charger, power supply, inverters, adaptors)
 - Prototyping capabilities – 3D printing
- In-House Design Verification & Reliability Testing
 - High voltage lab
 - Holds highest level of UL certification for in-house agency testing
 - System qualification for global agencies
 - In-house agency lab certified by UL & TUV



IN-HOUSE TESTING & CERTIFICATIONS

ENSURE SAFETY & RELIABILITY AND PEAK PERFORMANCE

- Three global testing locations
- 1,000+ charging/discharging channels
- Design verification team
- Onsite test capabilities:
 - Cell and battery pack safety testing
 - Cell performance
 - Environmental tests (IP6X)

Certified for all IEC and UL standard agency approvals

- UN38.3 [DoT]
- UL 991, UL 1998, & IEC 51508 for BMS
- UL 2595, UL2271, & UL 2580
- IEC 61960 & IEC 62133
- IEC 60950-1 & UL 60950-1
- IEC 62619



- **UL IECEE CTF Certificate. First approved in 2010**



- **UL CTDTP Certificate. First approved in 2016**



- **TUV Rheinland UA Certificate. First approved in 2009**



VERTICAL INTEGRATION

PROVIDES SEAMLESS SUPPORT FROM CONCEPT THROUGH EOL

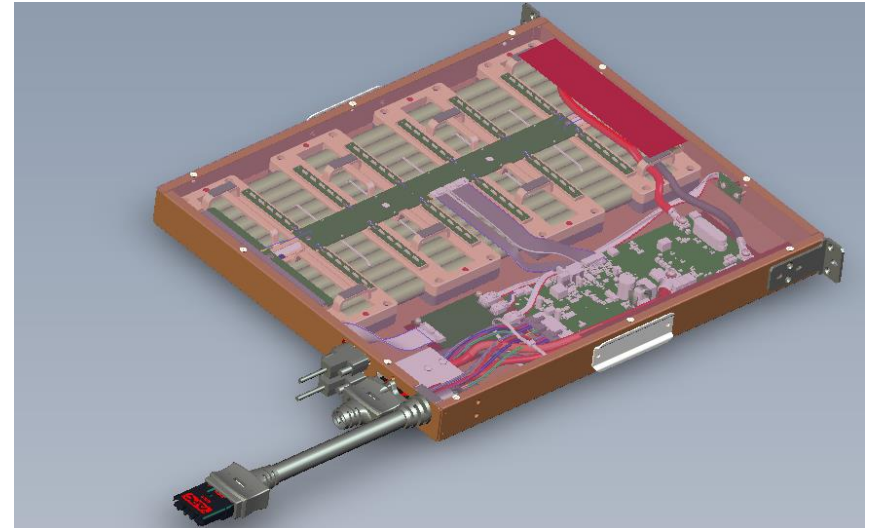
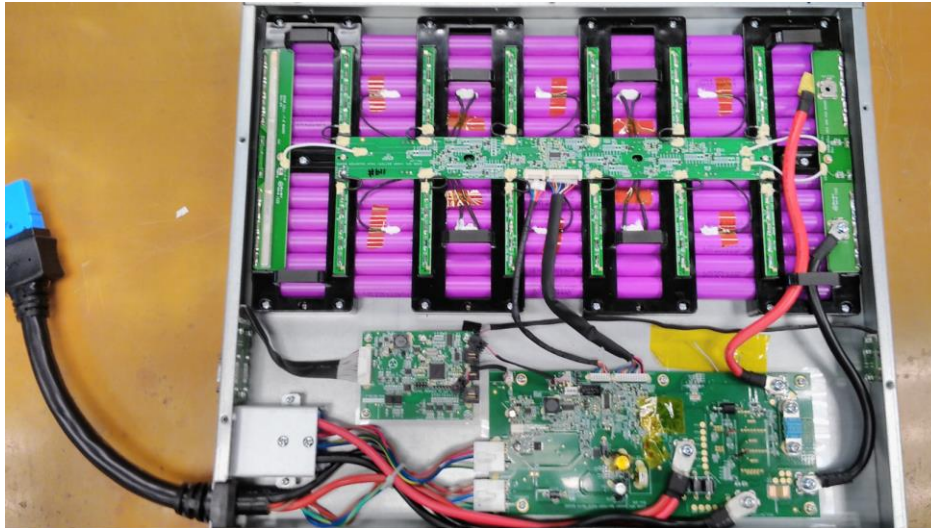
- Shorten lead-times and provide customers with turnkey solutions
- Engineering services
 - Cell selection
 - Electrical and mechanical design
- In house agency certification
- Manufacturing services
 - Battery pack, charger and power supply assembly
 - PCB layout and assembly
 - Resistance and ultrasonic welding & soldering
 - Conformal coating
 - Mechanical tooling and injection molding
 - “Clean Air” SMT production



TECHNOLOGY OVERVIEW

BBU FOCUS

48V 3KW BBU



- Unregulated 48V
- 60A continuous output capability for >5 minutes
- 14S6P configuration using 18650 NMC cells
- Hot swappable
- Load sharing capability between multiple BBU units
- 1U height form factor for rack mounting

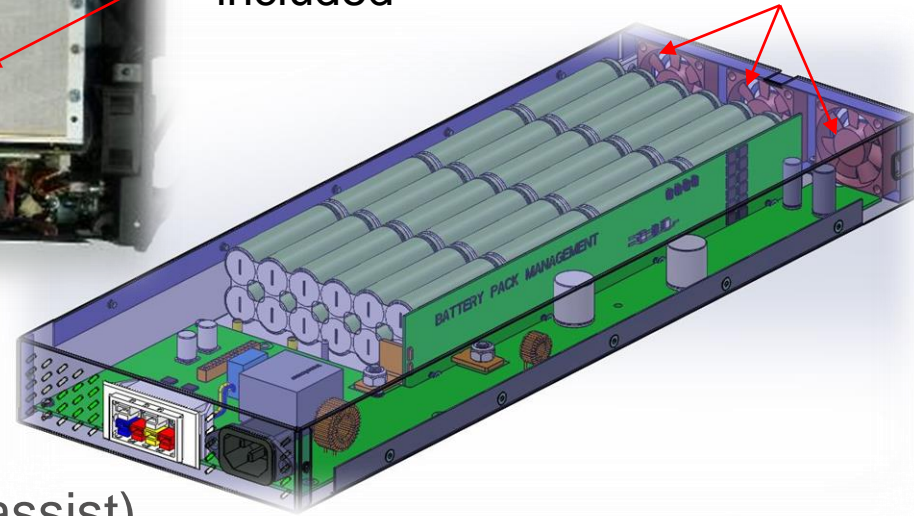
12V 3KW AC/DC BBU



DC-DC Buck/Boost
Converter channels

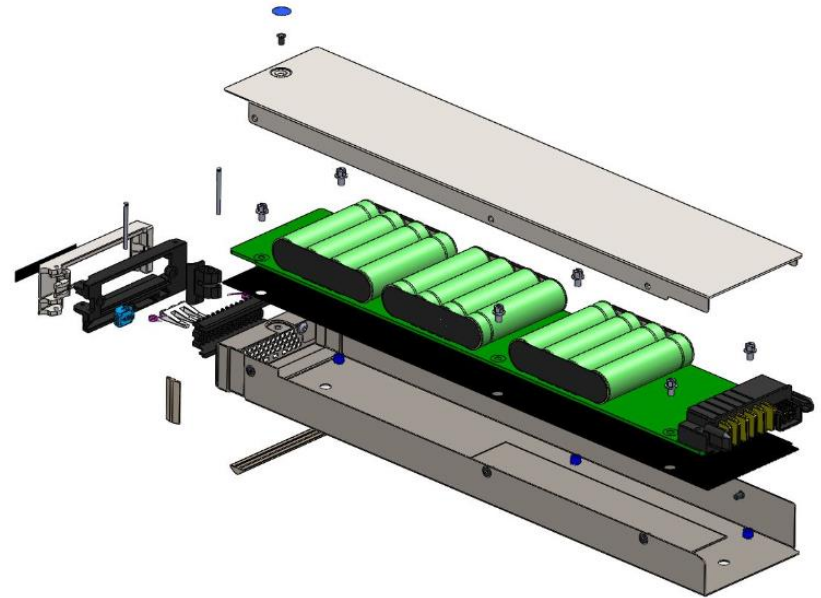
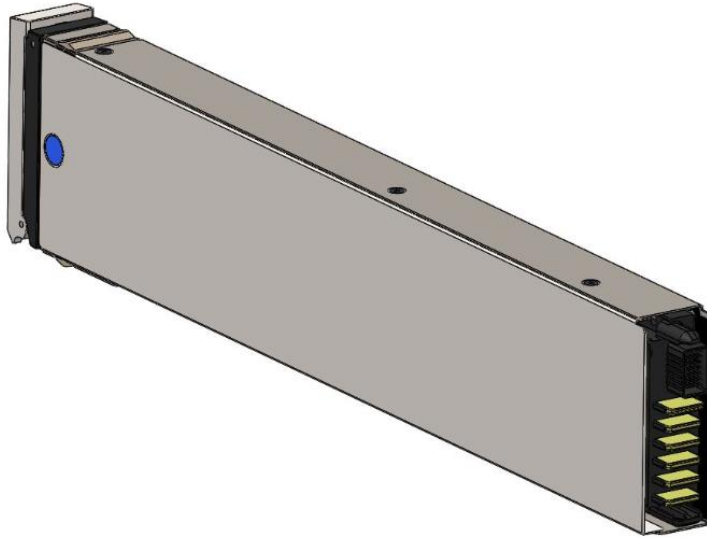
Heating element
included

Fans



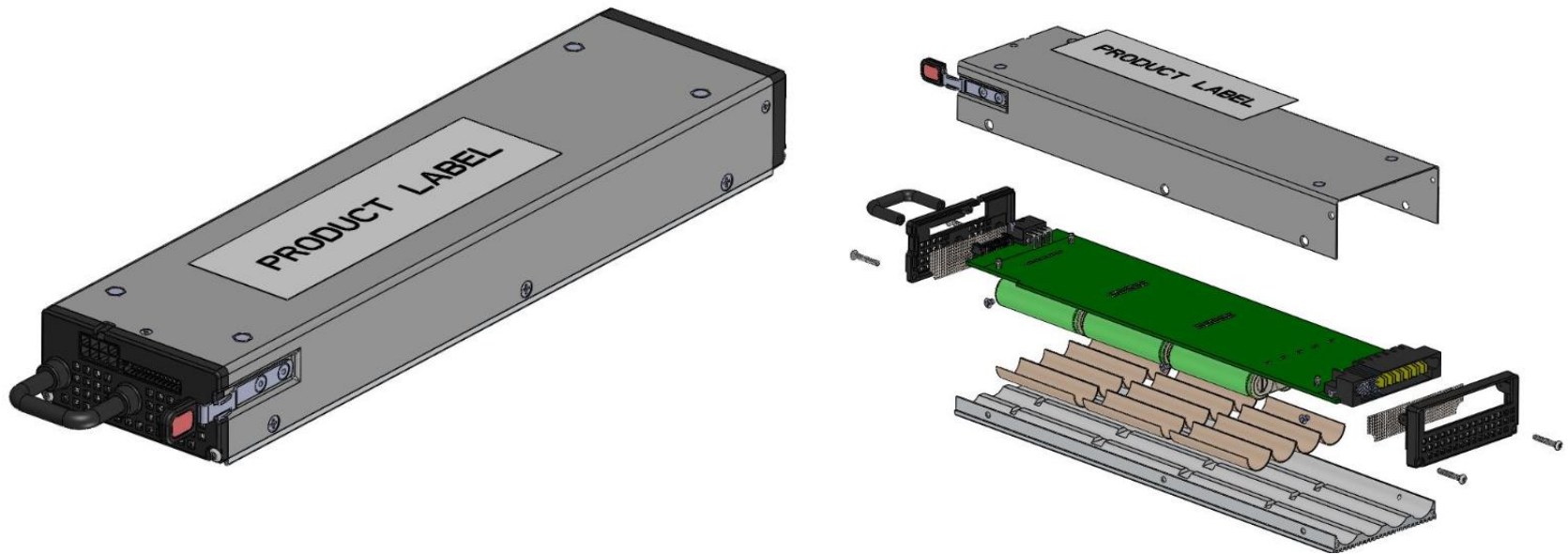
- Regulated 12V (BBU + peak load assist)
- 250A continuous output capability for >90 seconds from 0°C to 47°C
- 4S12P configuration using 18650 NMC cells
- Hot swappable with integrated AC/DC charger (<3 hours)
- Load sharing capability between multiple BBU units
- DSP controlled multi-channel high efficiency DC/DC Buck/Boost topology for rapid load response and output stability

12V 1.5KW BBU



- Regulated 12V
- 125A continuous output capability for >30 seconds
- 3S3P configuration using 18650 cells
- Hot swappable with integrated DC/DC charger (OR'ing)
- Load sharing capability between multiple BBU units
- Calendar Life: 2 years storage + 5 year operational life

12V 860W BBU



- Regulated 12V
- 72A continuous output capability for >180 seconds
- 3S4P configuration using 18650 cells
- Hot swappable with integrated DC/DC charger (OR'ing)
- Load sharing capability between multiple BBU units
- Calendar Life: 2 years storage + 5 year operational life

OPEN EDGE BBU PROPOSAL

OPEN EDGE (CHASSIS REQ'S)

- The Open Edge chassis consists of 6 sections
 - 5 useable sleds
 - 1 sled dedicated for a primary & secondary PSU and the rack management controller
- 1U sled, Addr 1 can support either server or battery backup unit (BBU)
 - Twin Power connectors - Each 85A
 - Expected BBU output 133A @ 12A

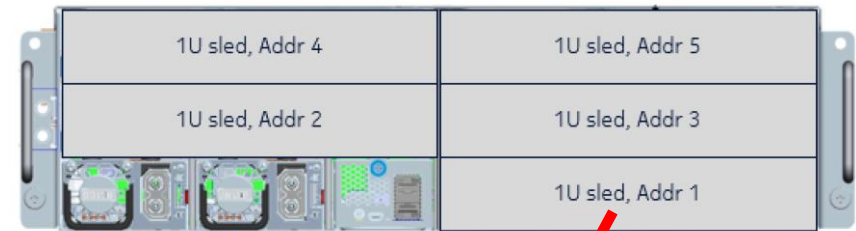
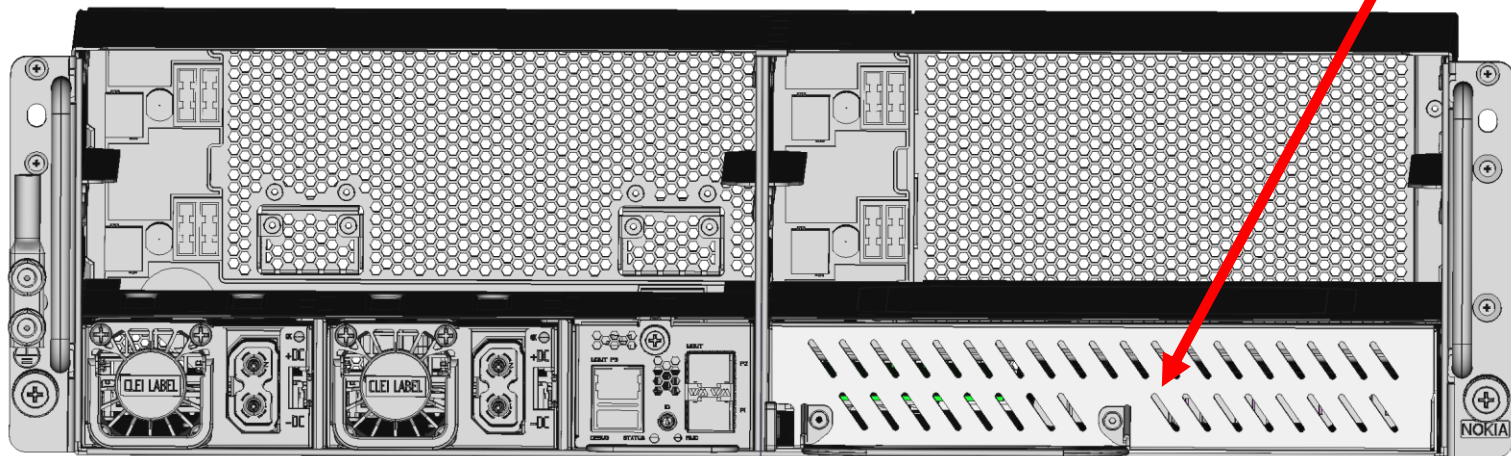


Figure 7 Open edge chassis with five 1U sleds



OPEN EDGE (CHASSIS REQ'S)

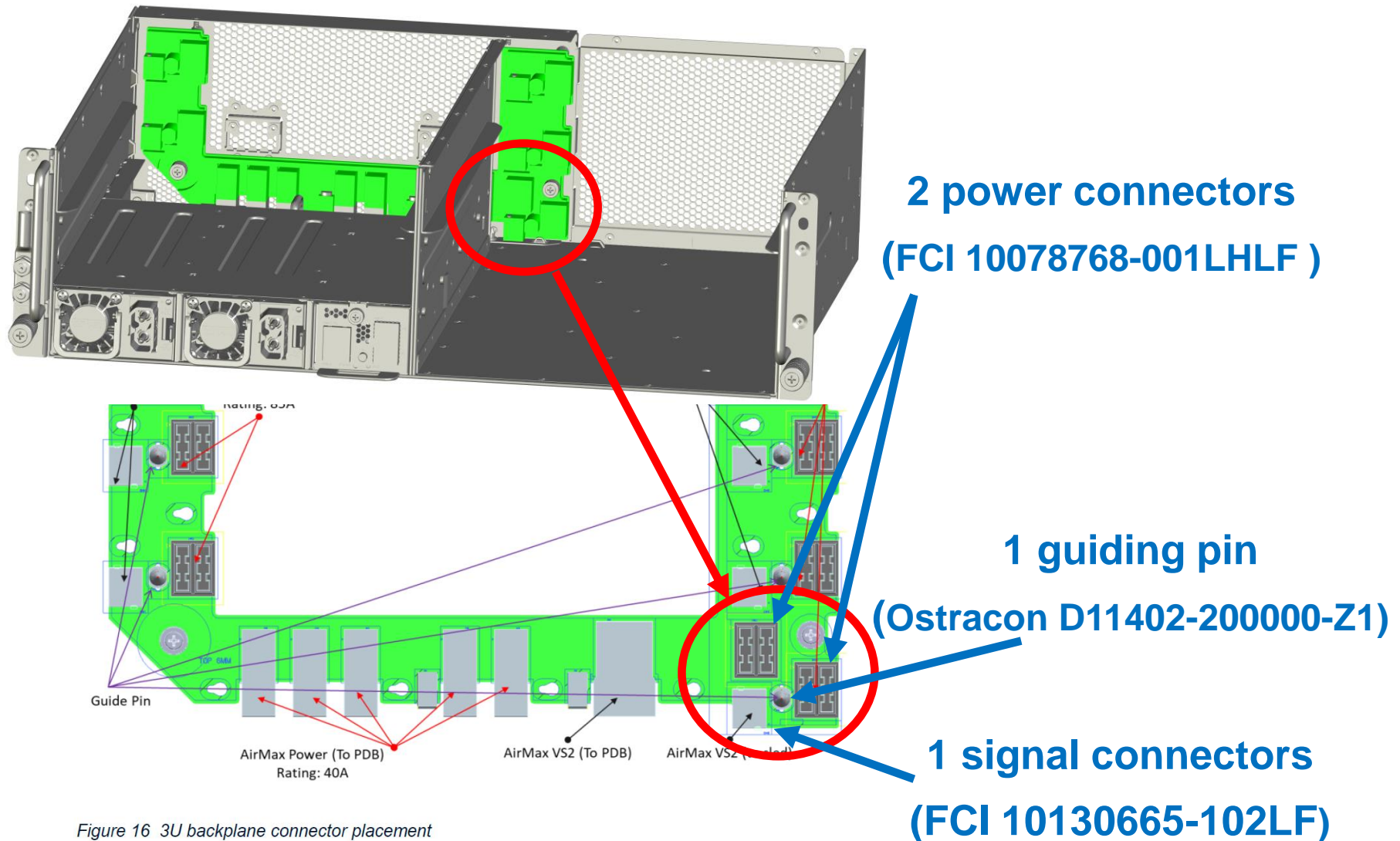


Figure 16 3U backplane connector placement

OPEN EDGE (BBU REQUIREMENTS)

- Mechanical enclosure based on Open Edge sled with minor tweaks
- Connector
 - Power: FCI 10078770-002LHLF (2x)
 - Signal: FCI 10124149-102LF (1x)
 - Guiding Receptacle: Ostracon D11403-000A00-Z1 (1x)
- P, I, V
 - Power: 1600W continuous (400W per sled, 4x sleds supported)
 - Current: 133A continuous (2x FCI power connector supports up to 170A)
 - Voltage: 12V regulated output
- Communication
 - SMBus (SDA, SCL)
 - Digital and Analog Pins: ALERT, PRSNT and PD (Physical Address)
- Target at least 120 seconds or more of continuous power
- Hot swappable with integrated DC/DC charger off the 12V bus

CELL TECHNOLOGY

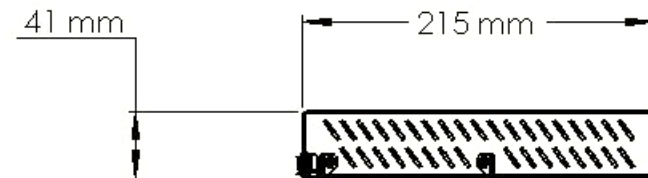
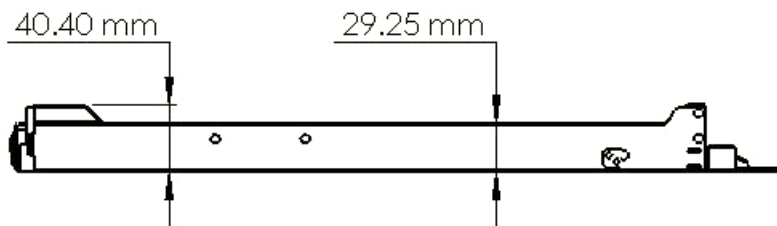
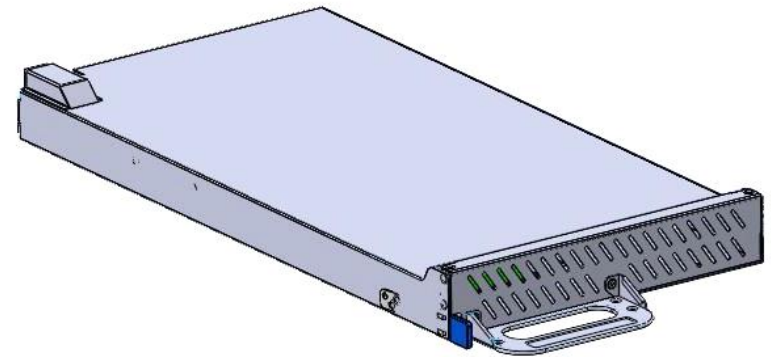
- What cell technology is the right choice for Open Edge?
- What fits?
 - Prismatic Pouch (soft rectangular enclosure)
 - Limited footprints & supplier options
 - Requires rigid enclosure to manage swelling/handling
 - Prismatic Rigid (hard rectangular enclosure)
 - Limited footprints that fit Open Edge sled (this includes VRLA replacements)
 - Cylindrical
 - Several options available in 18650, 21700 and 26650 packages
 - Several suppliers and chemistries to choose from
 - Easier to scale capacity upward if more run time is required
 - Easier to scale capacity downward if less run time and power is required
 - Possibility of integrating non-BBU electronics to utilize dead space

CELL TECHNOLOGY (CONT'D)

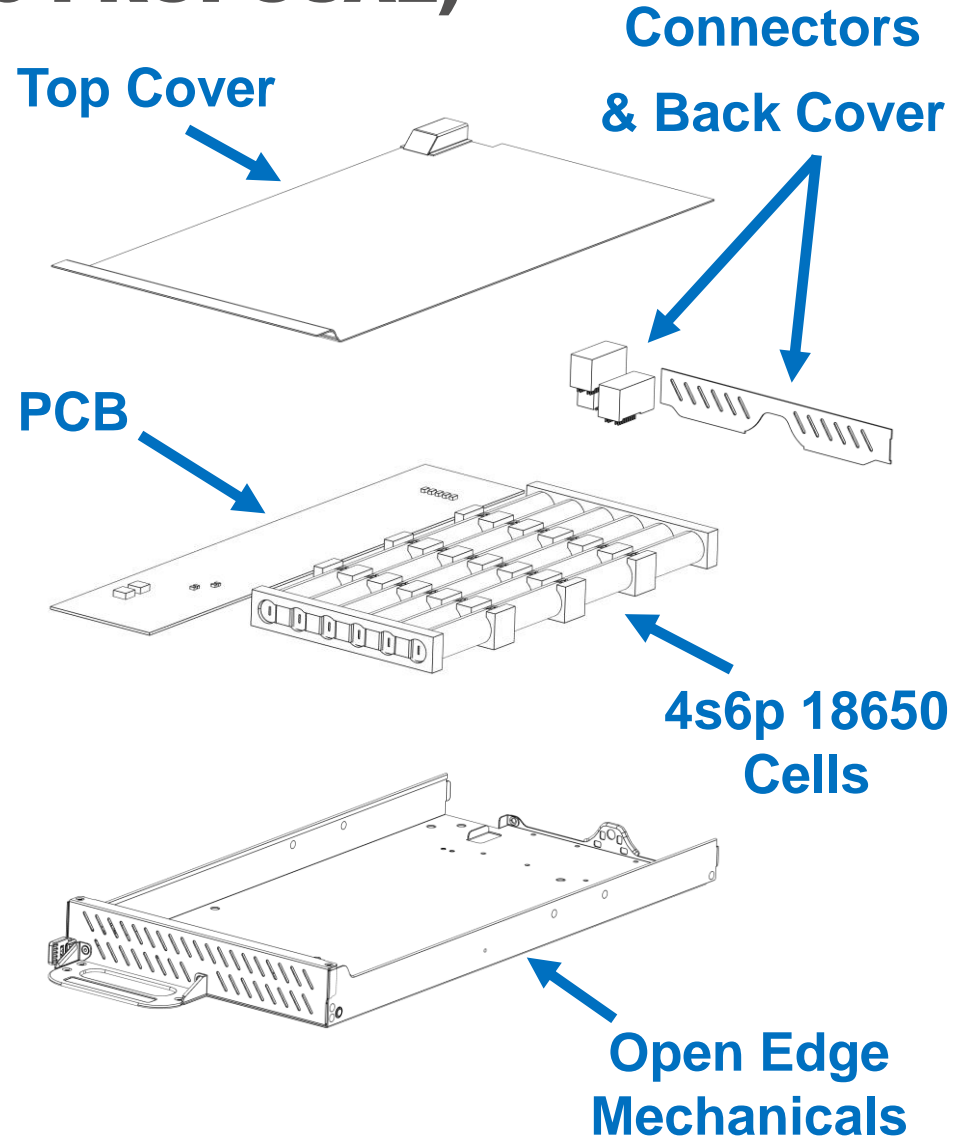
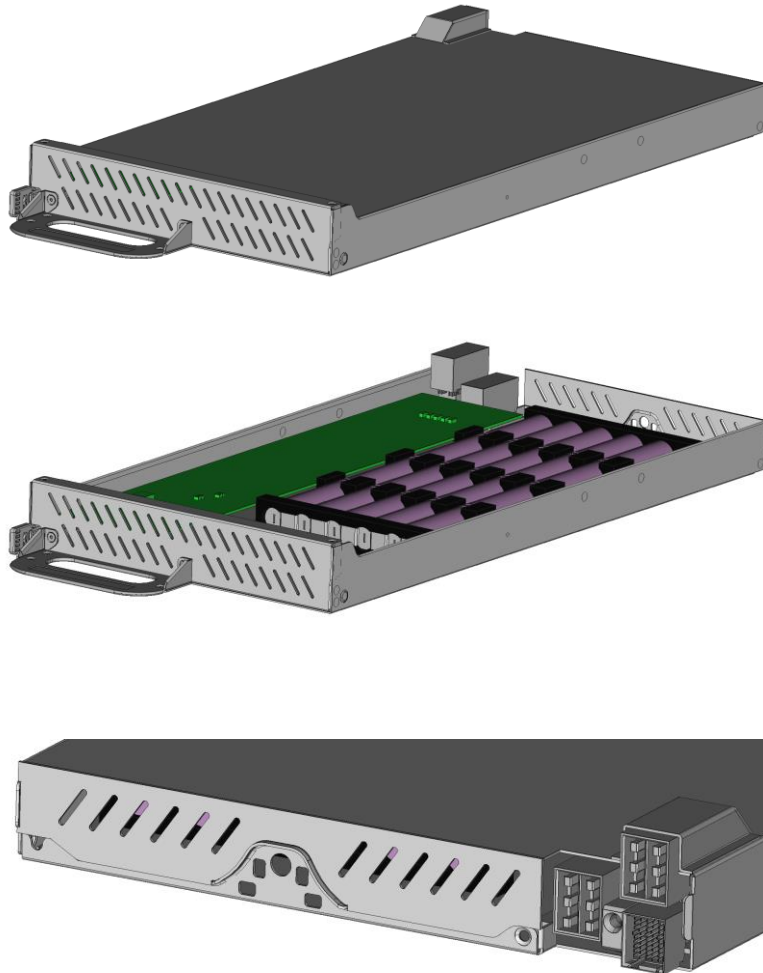
- What chemistries make the most sense?
 - Table below only considers the most relevant and widely used in the BBU space
 - LFP would seem to be the clear choice if based on safety, long life...however,
 - Higher cost, lower energy density, flat discharge curve and a larger space envelope required
 - NMC/NCA has been used for 10+years in BBUs safely and with long life

Cathode Material	Average Voltage	Voltage Range	Specific Energy Density	Safety Index	Comments
	V	V	mAh/g		
$\text{Li}(\text{Ni}_{1-y-z}\text{Co}_y\text{Al}_z)\text{O}_2$ NCA	3.6	4.2-2.5V	~190	◆◆	High capacity Medium Rate
$\text{Li}(\text{Ni}_{1-y-z}\text{Mn}_y\text{Co}_z)\text{O}_2$ NMC	3.6	4.2-2.5V	~155(~170)	◆◆◆	High capacity High rate. Up to 811 today
LiFePO_4 LFP	3.2	3.65-2.0V	~145	◆◆◆◆ very safe	Low capacity High rate Excellent cycle life

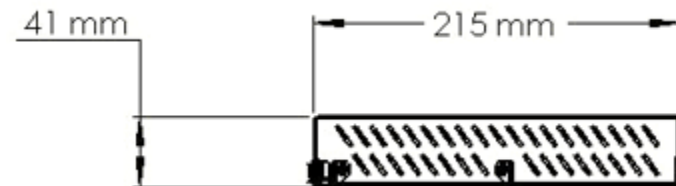
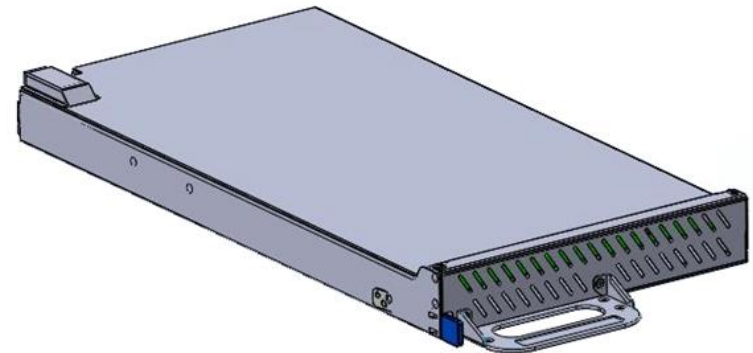
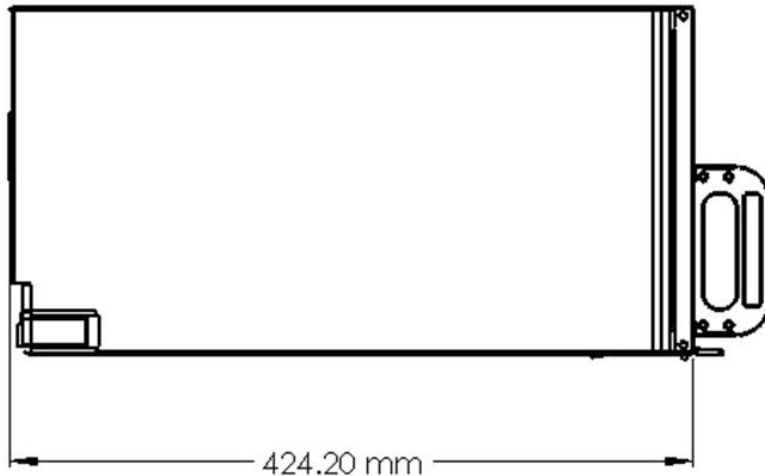
OPEN EDGE (BBU 18650 PROPOSAL)



OPEN EDGE (BBU 18650 PROPOSAL)

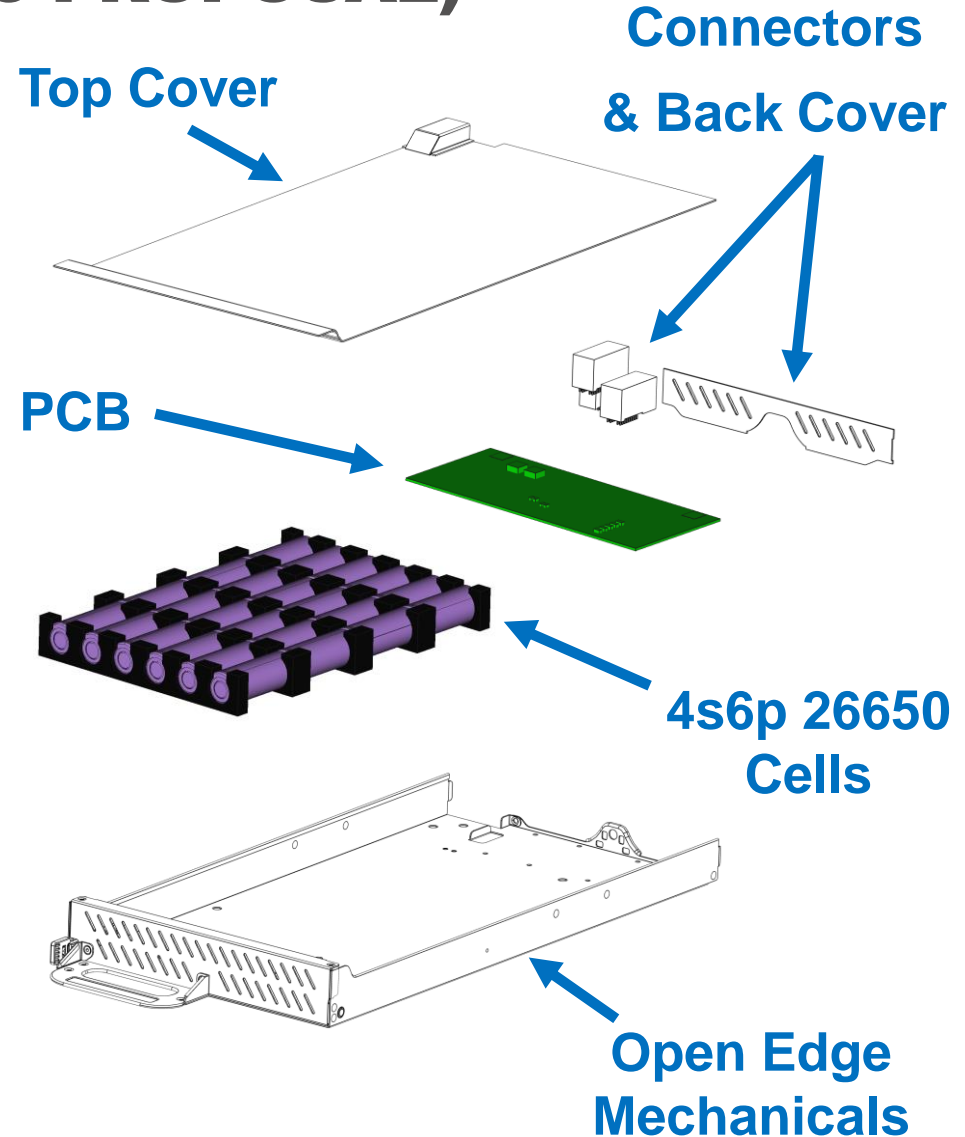
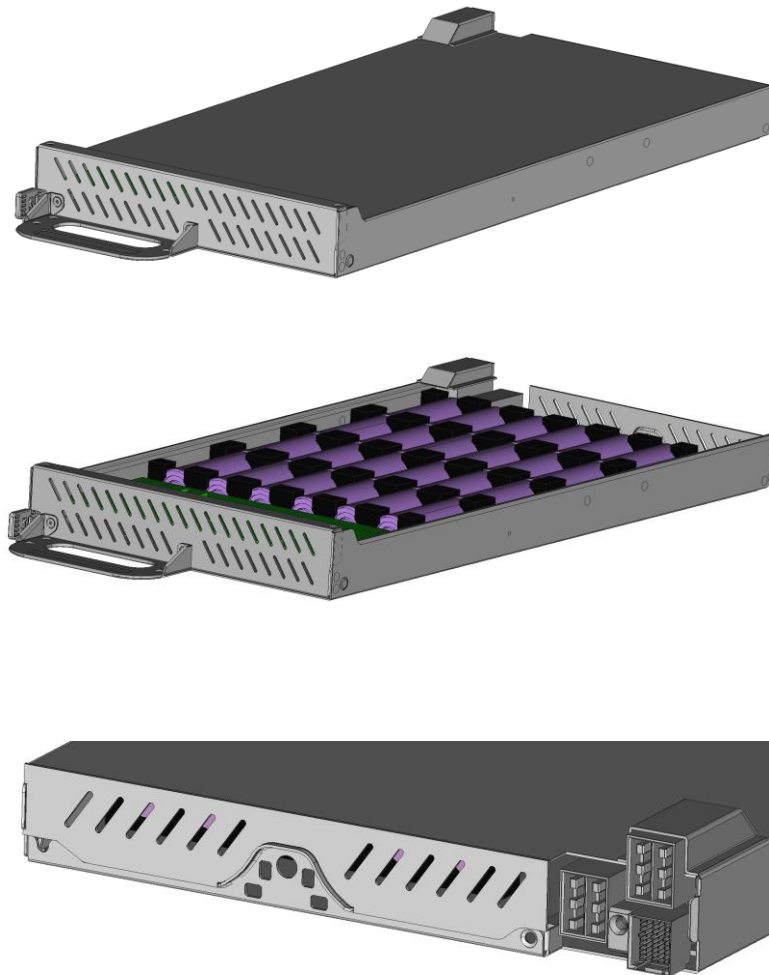


OPEN EDGE (BBU 26650 PROPOSAL)



**Increase center height from 29.25 mm to 31.82 mm,
still easily fits within height constraints**

OPEN EDGE (BBU 26650 PROPOSAL)



OPEN EDGE – BBU QUESTIONS

- Supporting Server for graceful shutdown – is 2 minutes sufficient?
- Data Storage blades in system?
 - If so – How much backup time?
 - Industry standard from 3 to 5 minutes
- Expected Life?
 - Assuming 5 years (or is it more)?
 - Run-Time ratings degrade over time – Need to specify “New” vs. “Life End”
- Cooling or Heating options
 - Initial design around natural convection for reliability and lower cost
 - Is there a demand for a wider temp range product as a product extension?
- Front Panel – any indicators or information display needed?
- Other Options?

THANK YOU



OPEN
Compute Project[®]