

# Power Budgets and Management

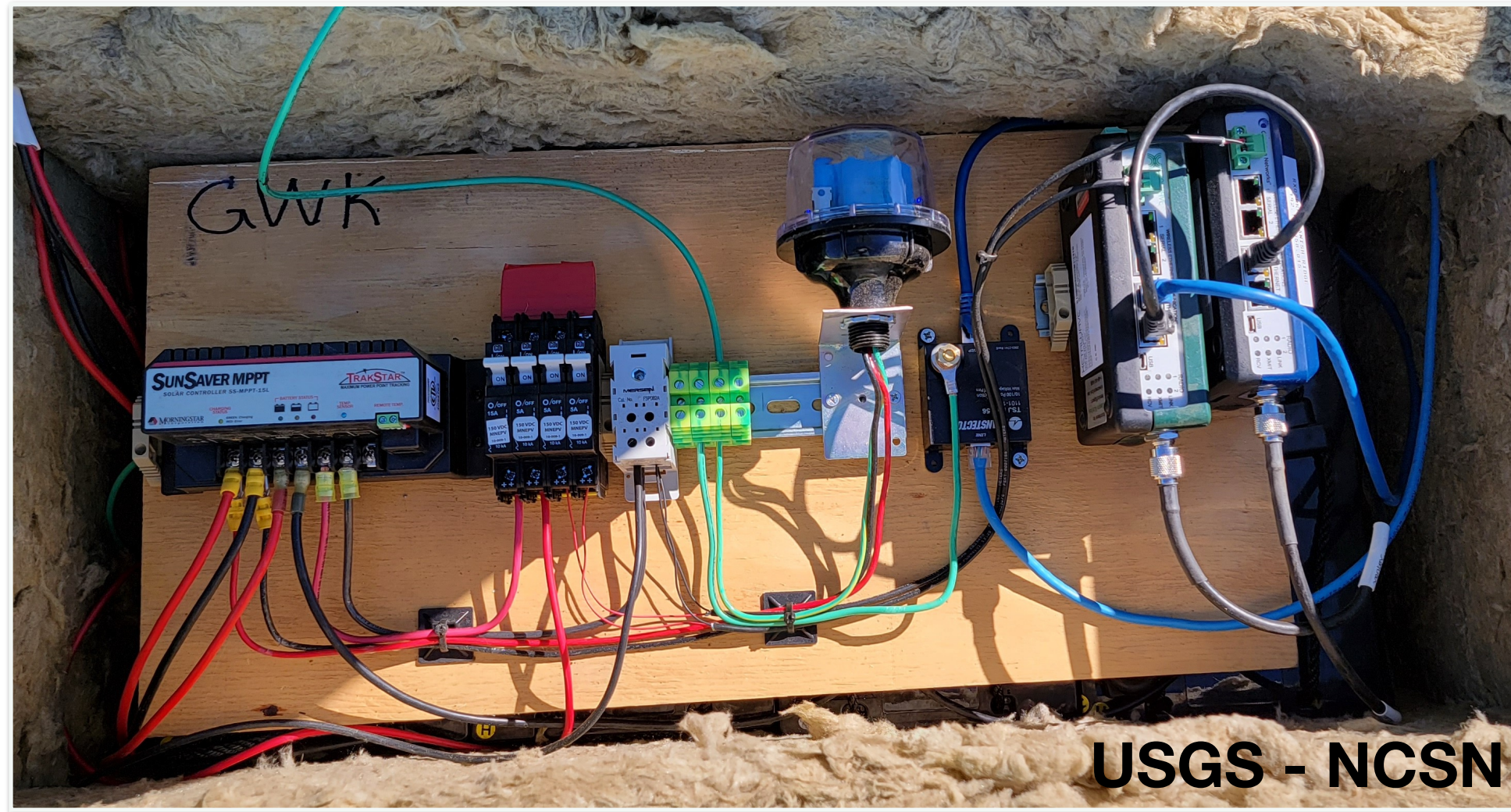


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# What are you using for Power Generation and Storage?



## USGS - NCSN

- One 200W panel (formerly two 100W)
- MorningStar SunSaver 15A MPPT
- Four 12V Sun Extender AMG (fancy LAB) in parallel
- For solar boost: 350W panel, Morningstar ProStar 25A charger, same batteries

## Montana

- Almost all solar panels with 12V LAB (AGM if possible)
- Rare AC power at stations/repeaters

## TexNet

- 160W Sunrise Solar Panel
- SunSave MPPT Charge Controller
- Two 105Ahr Hr Gel

## CERI (NM, ET, AG)

- Majority of stations are solar, strive for 25:1 power ratio
  - Meaning 5W load gets 130W solar
- Victron Energy MPPT SmartSolar
- Four GRP 27 100Ahr AGM batteries

# What are you using for Power Generation and Storage?

## Utah - Solar

- Misc panels 10-300W
- FlexCharge (NC12L12), VLF Designs (SR-2, SR-4, SR-5b, BC-4, BC-10), MorningStar (ProStar-15, SunSaver MPPT)
- 6-12V LABs (79/220Ahr) and 12 Air Cell (V/1200Ahr)

## Utah - Urban

- Sola-HD SLS-12-017T L-Frame AC/DC Converters w/ 12V/92Ahr batteries (typically)
- AC Power Adapters

## SCSN

- 211 solar powered and 167 AC-powered
- Deep cycle batteries for backup at all
- Generator backup at some
- Variety of different solar controllers, panels, and AC-chargers (Victron energy, MorningStar, ProMariner, etc.)



Utah

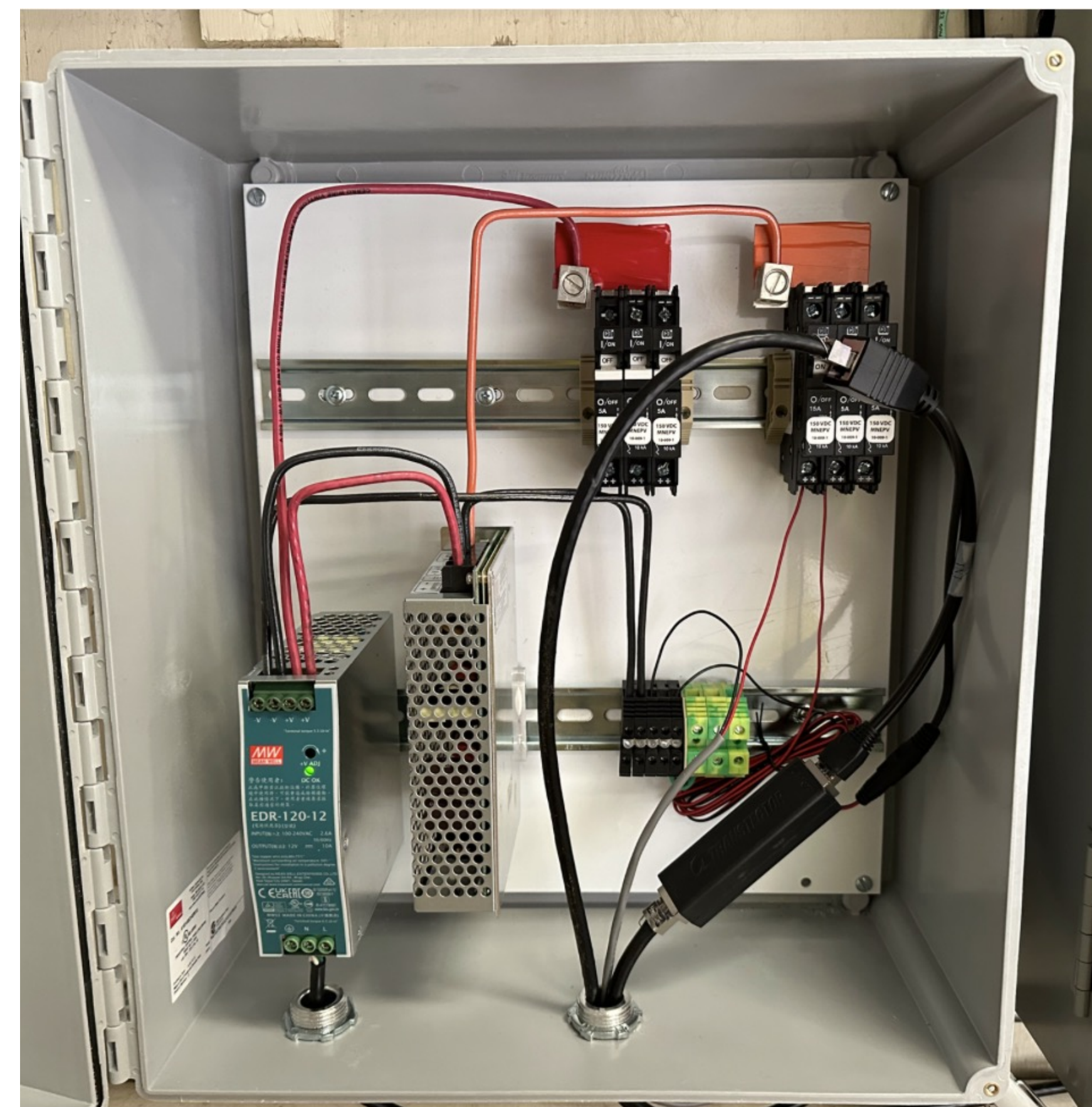
## South Carolina

- One 330-390W solar panel
- Midnight Solar TheKid charge controller
- KiloVolt Li battery (with bluetooth)

# A / C Seismic

NN\_MOHS

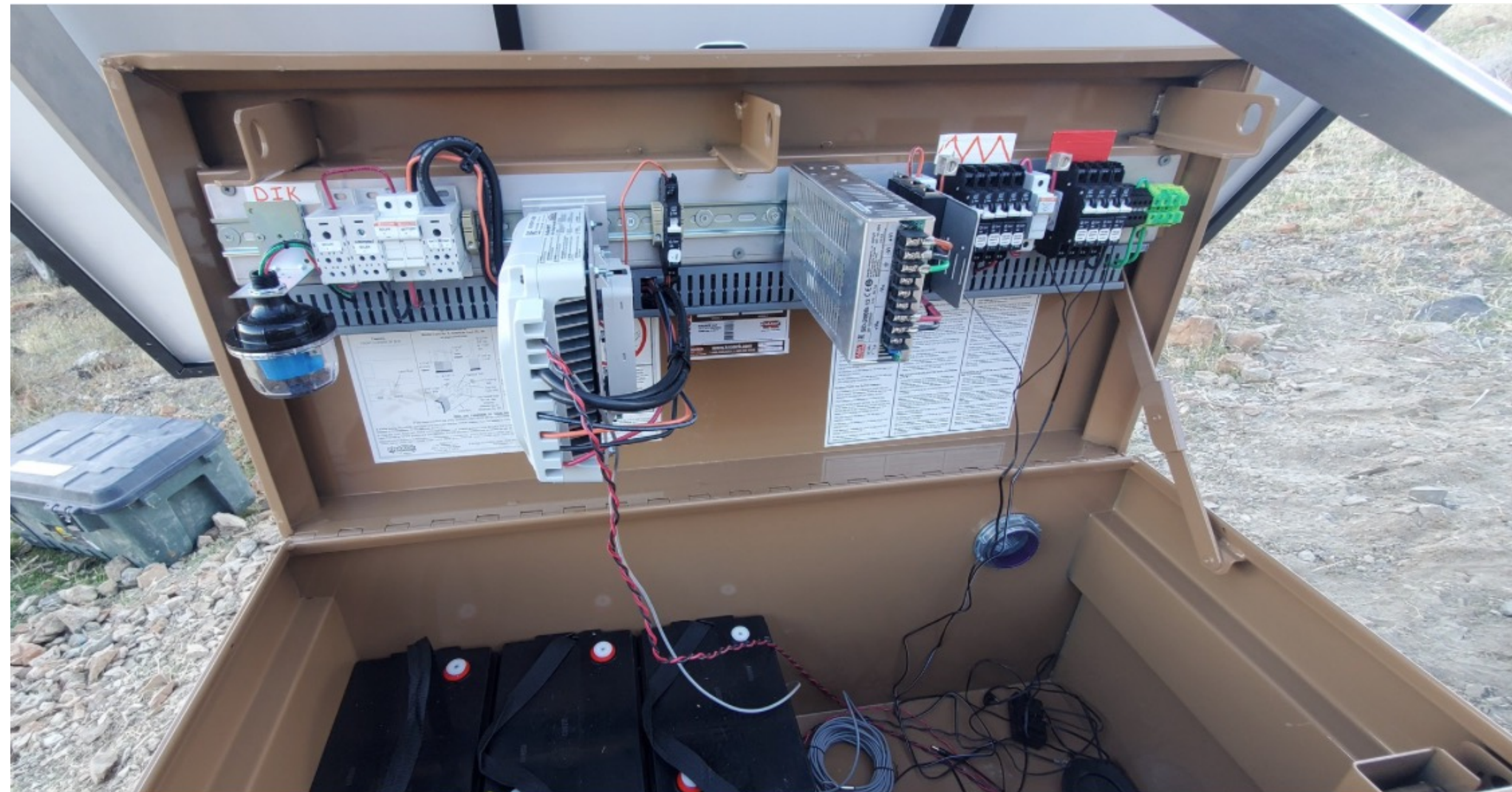
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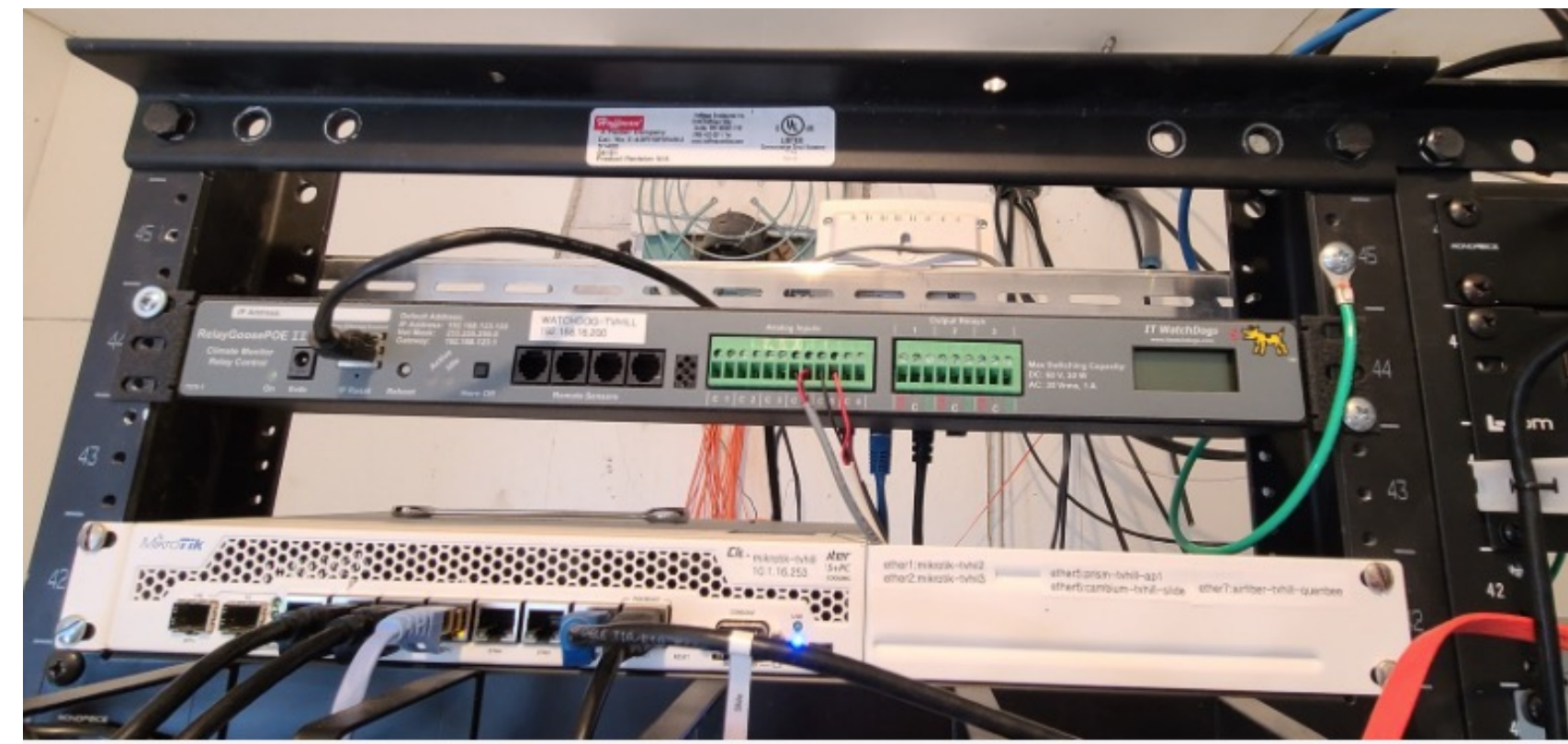
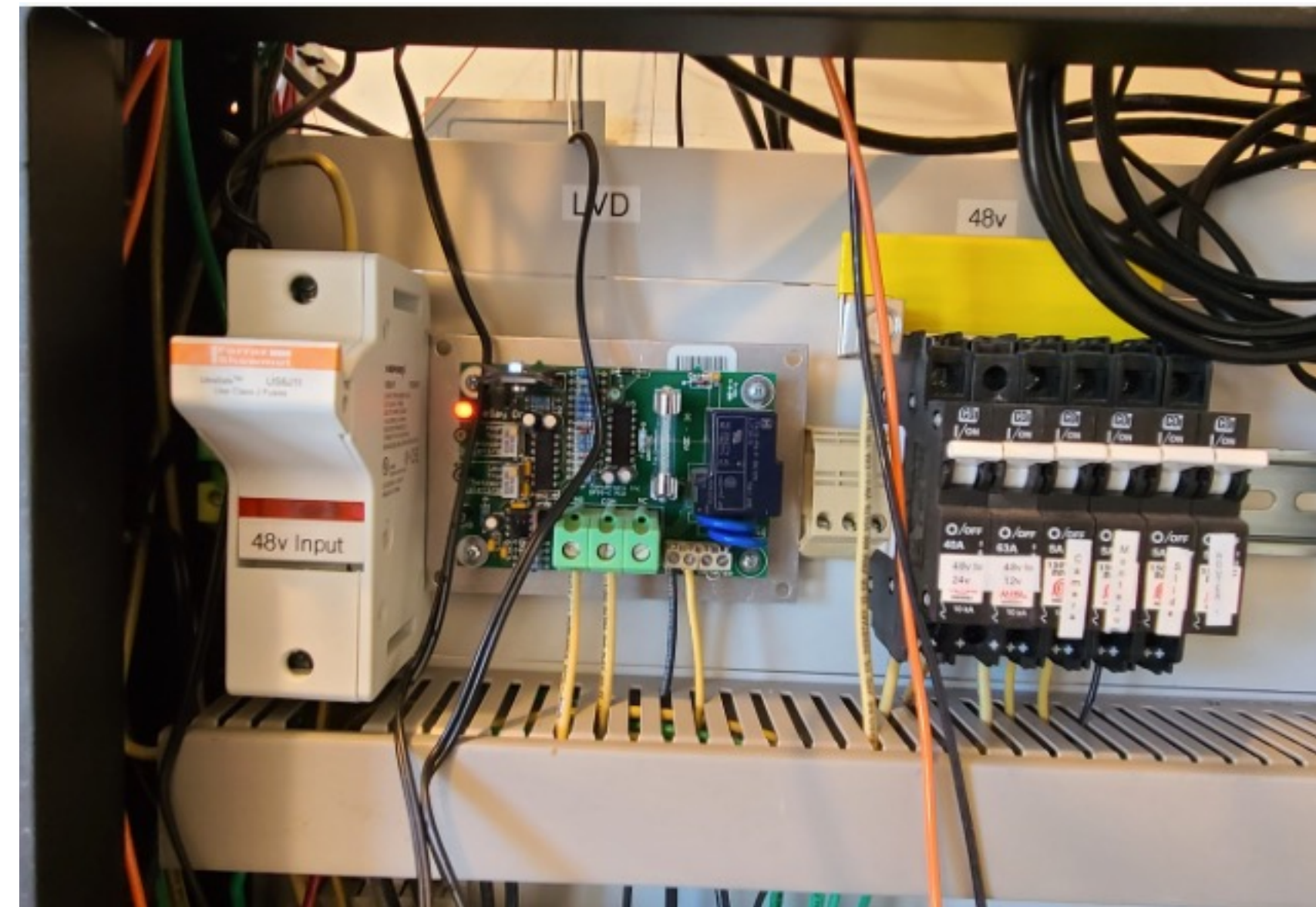
# 12V Seismic



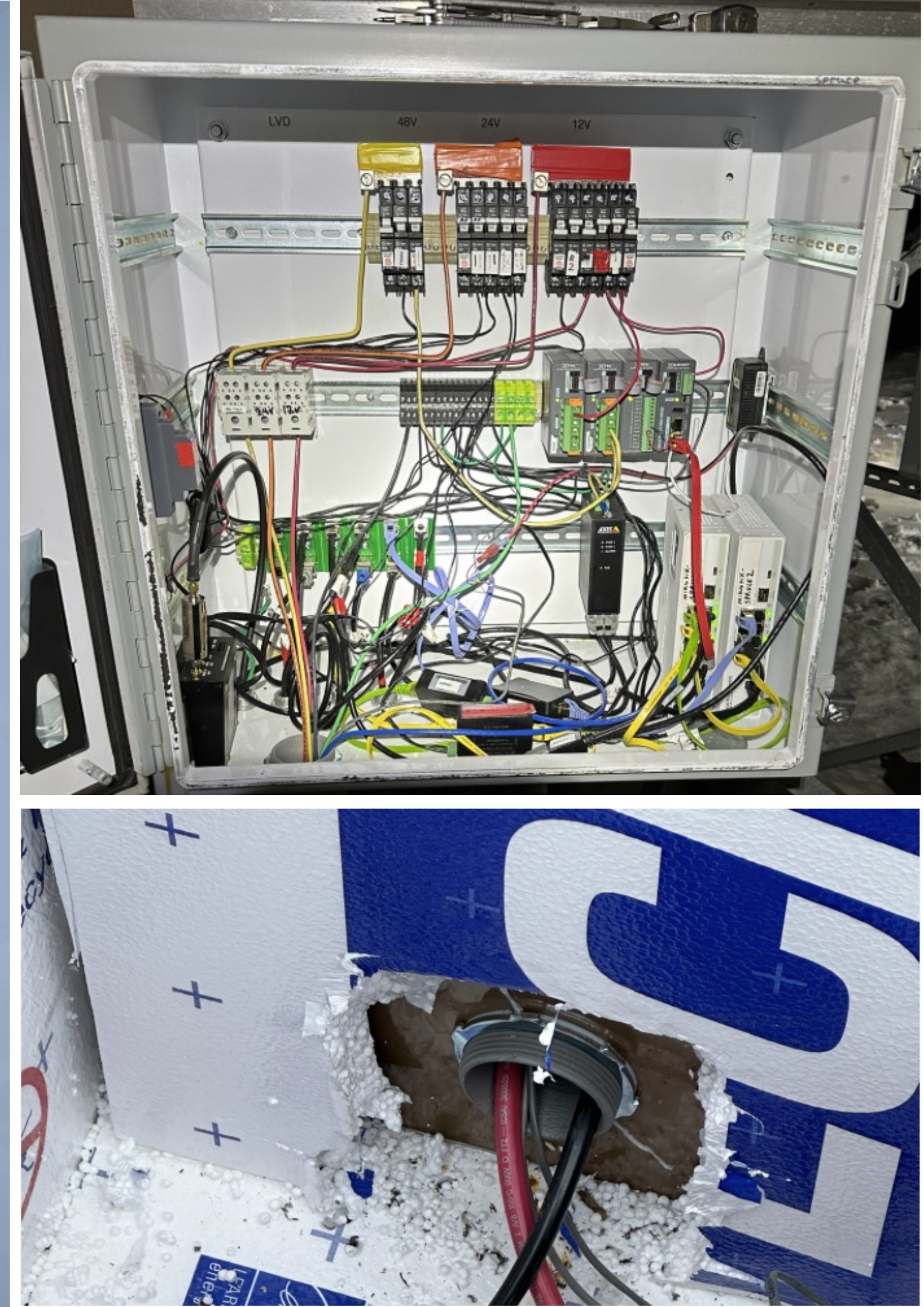
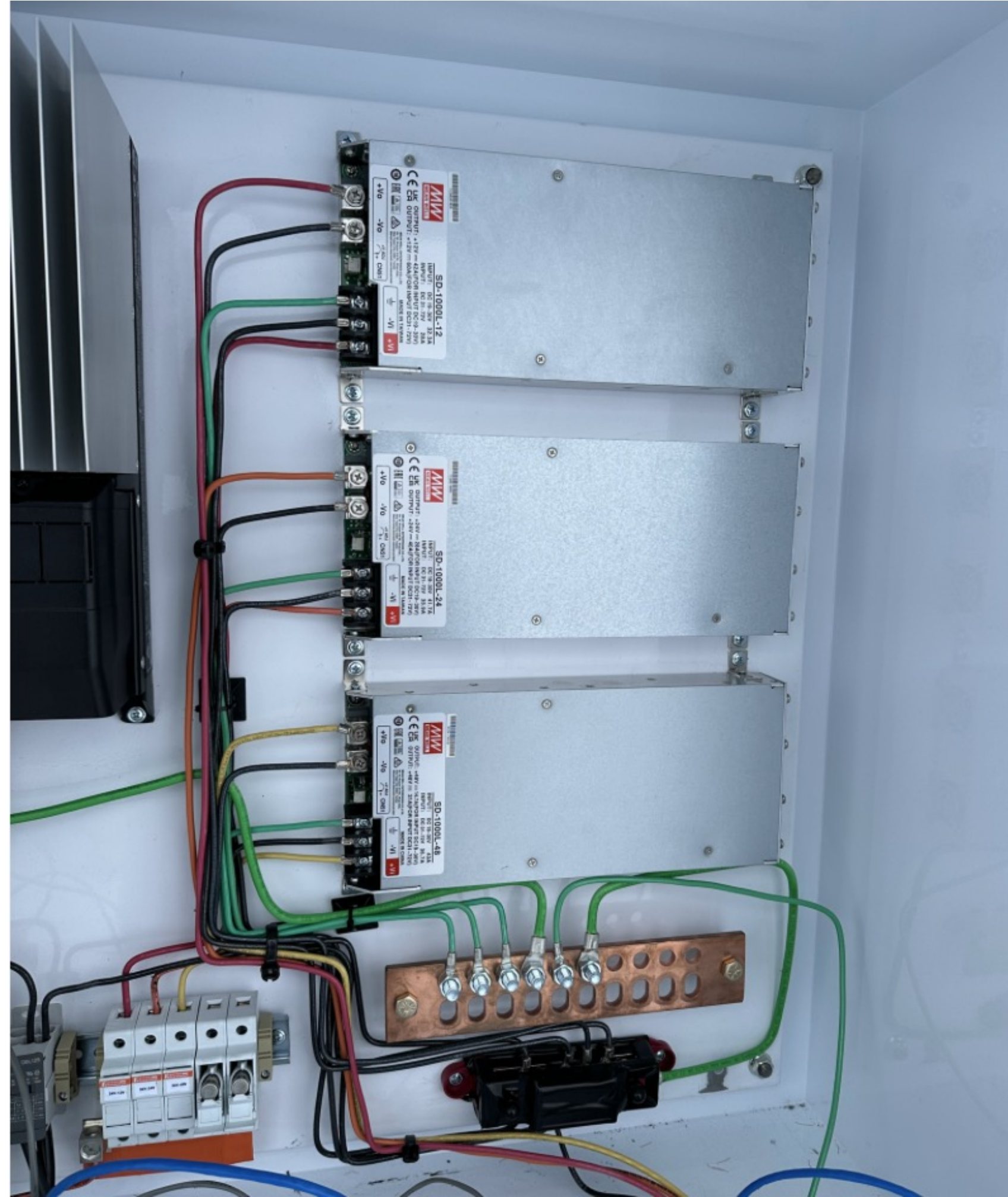
# 24V Seismic Kit (New design)



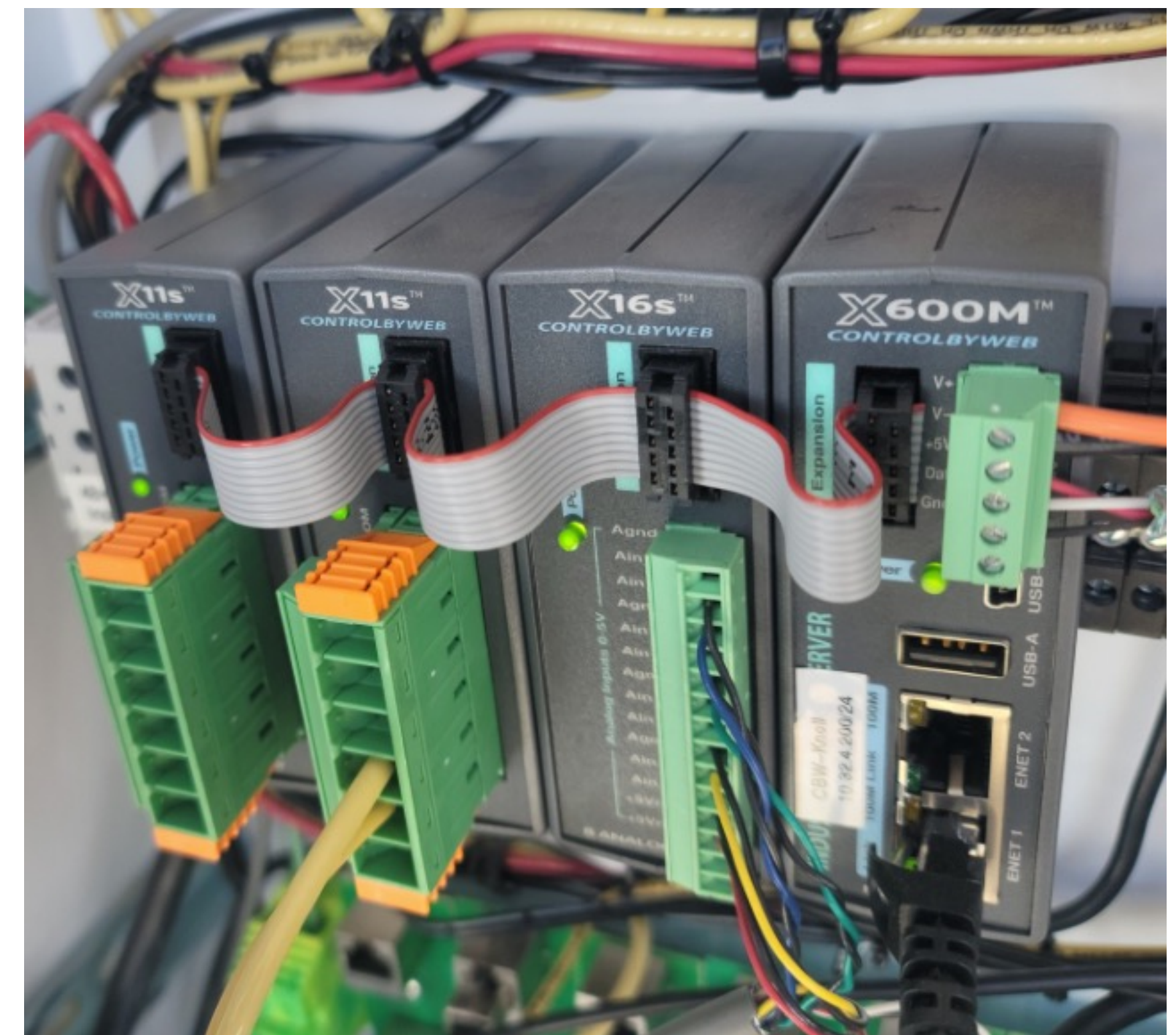
# Major Comm Site



# 24V Camera Site



# 48V Camera Site



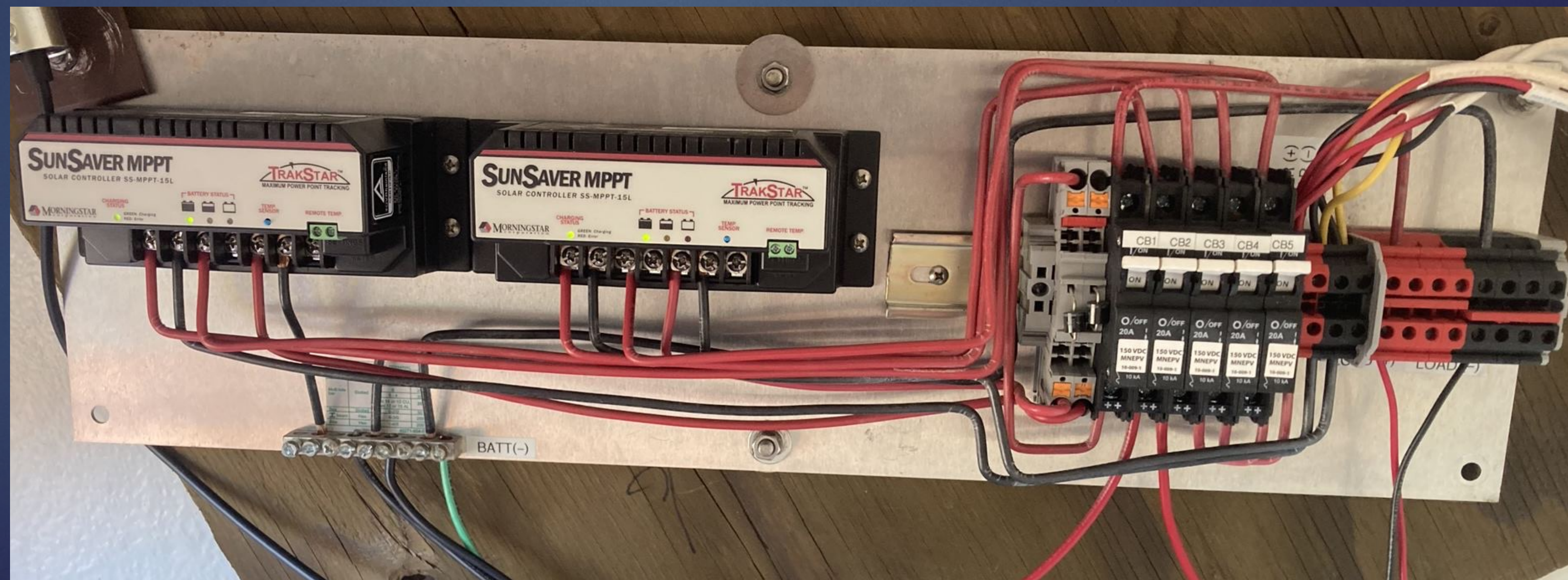


# CVO Power Systems

- CHARGE CONTROLLERS: MorningStar SunSaver MPPT 15-L
  - 12V and 24V systems (switches intelligently)
  - AC: Use in-line with Mean Well CLG-150-15C AC/DC Power Supply to charge backup battery
- Sun Xtender PVX-1040T batteries (12V, 104Ah AGM)
  - seem to perform well in varying temperatures; no history of defects
  - Addition of air cells in locations with deep snow
- Various solar panels, primarily 12V nominal monocrystalline
- Power levels are monitored using voltage outputs from digital radios

# CVO Power Systems

- Diode steering for redundant solar charging systems
- Backups in case of MPPT failures (common in dry environments, manufacturer has been unable to determine cause)
- Multiple solar panels at different angles, sometimes exceeding current input of a single controller
- Pre-built “power distribution” panels simplify wiring in field



# Power Generation - Solar



390W solar array – occasional triple panel setup when needed

# Power Storage

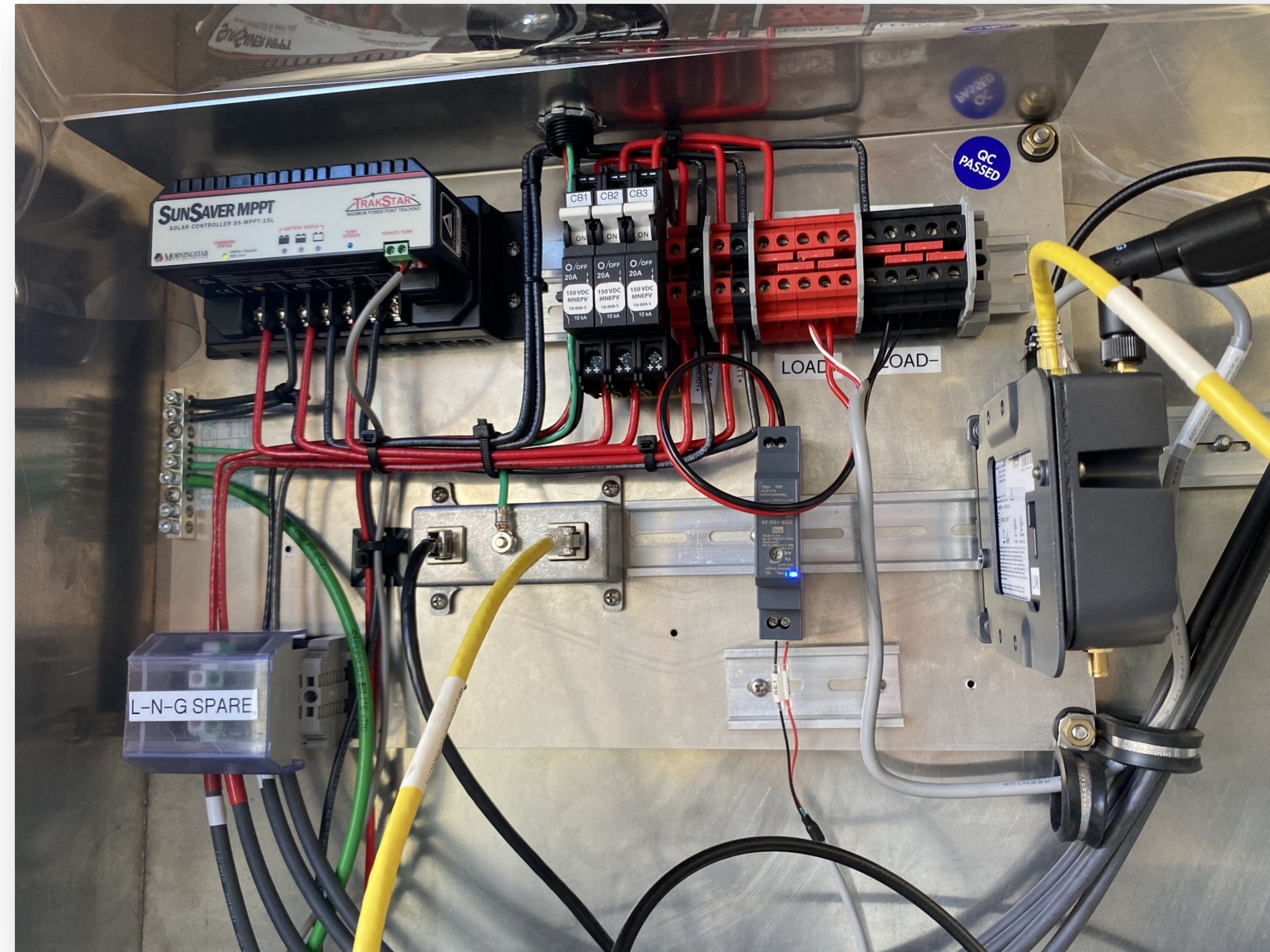


Solar: 400-1000Ah in 24V (Mostly 400Ah)  
Hosted: 100Ah back-up battery



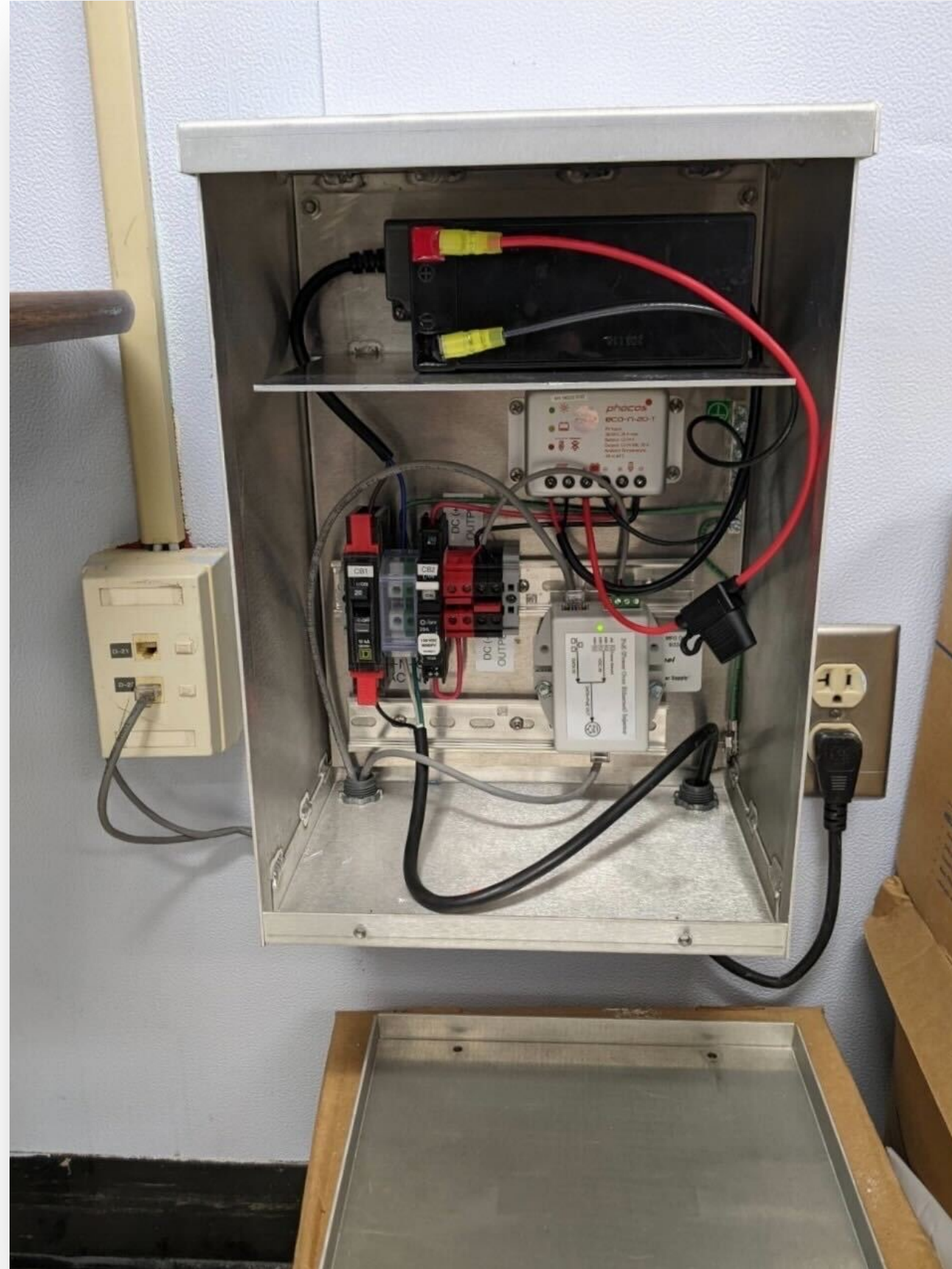
Aircell back-up banks at  
4 critical remote stations

# Power Distribution



Standard panel at all PNSN sites

# Power Conversion – Hosted



AC-to-DC conversion, with UPS for local devices if needed



## Power Generation - Solar



810W solar array (2 panels in series, 2 in parallel)



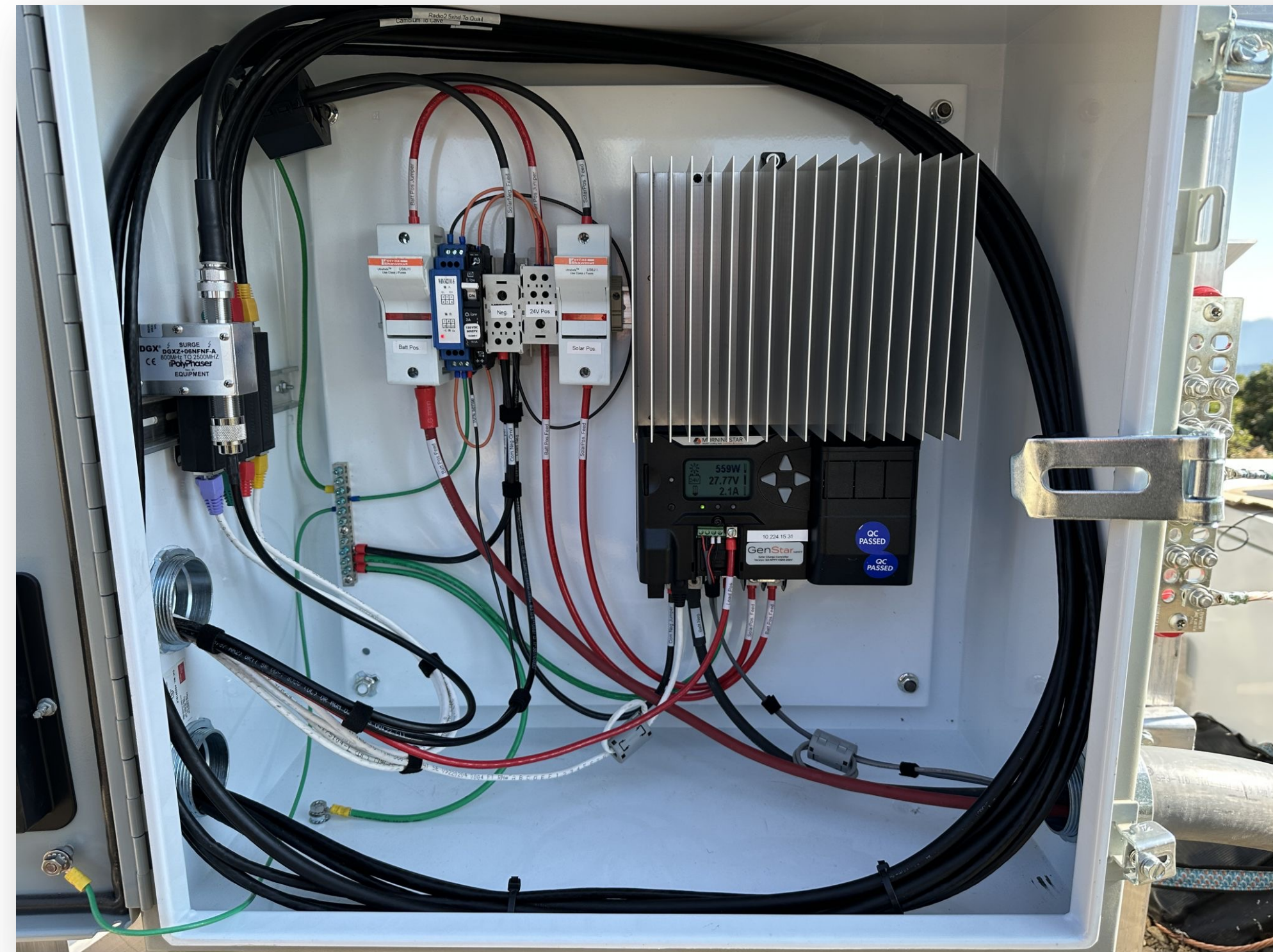
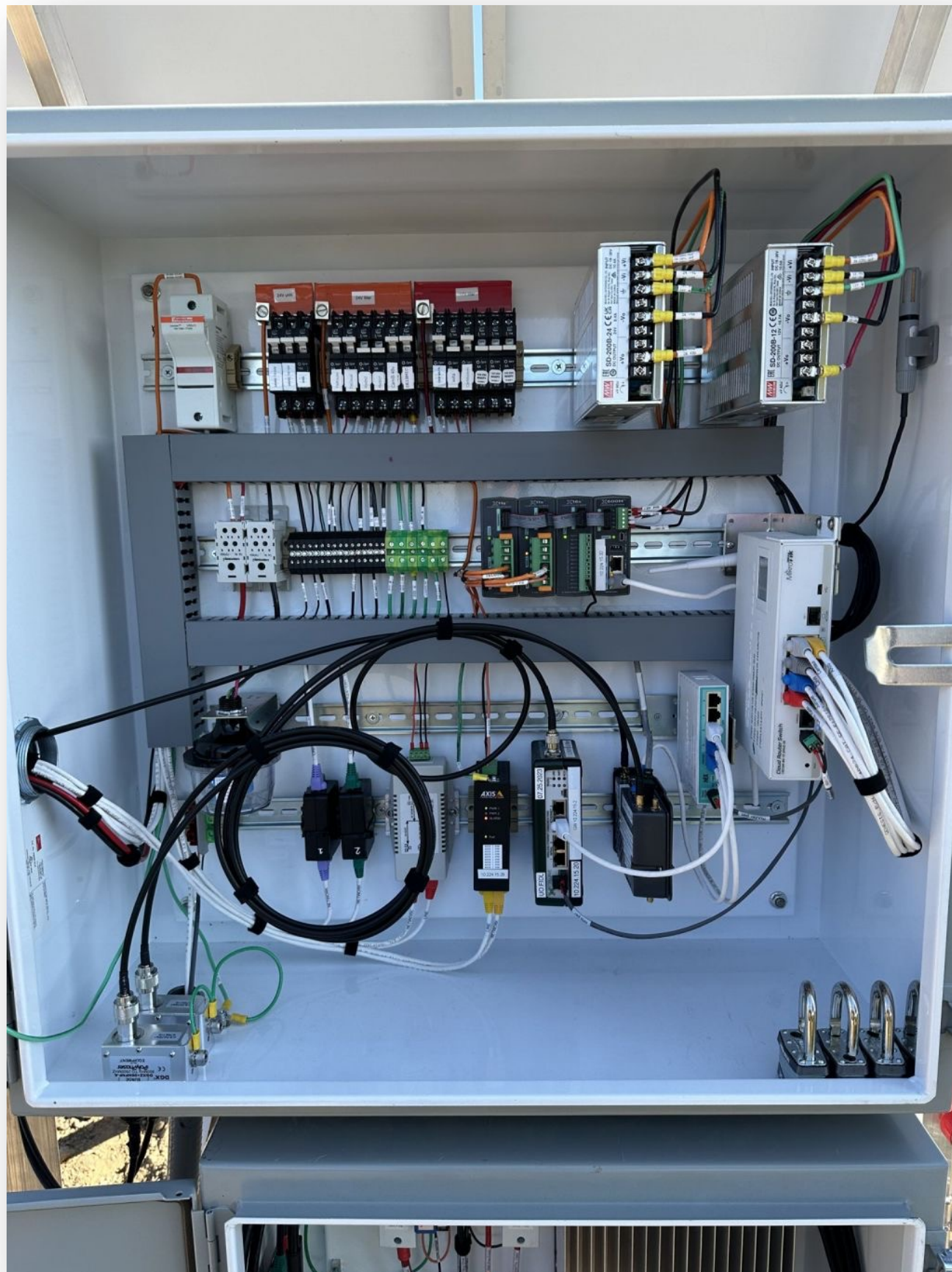
## Power Storage - Solar



Deka gel 265Ah batteries 4p2s (1060Ah total at 24V)



# Power Distribution - Solar





## Power Distribution - Comms Facility

Power over  
Ethernet supplies

UPS and Smart PDU

Surge suppression

Router



# What are the biggest consumers of power at your stations?

## USGS - NCSN

- Radios
- Cell modems

## Utah

- Raspberry Pis
- Cell Modems
- Sensors
- Radios

## CVO

- Radios
- GNSS Receivers

## Montana

- At analog stations - FM radios
- Data loggers (usually)

## CERI (NM, ET, AG)

- Radios
  - 900 MHz Xetawave X9 draws 3-4W of a 5W station load

## SCSN

- VSAT

## Nevada

- Radios
- Cell modems
- Fire cameras
- Routers

## TexNet

- Modems
- Dataloggers



## Biggest Power Consumers



### Axis Q6075-E camera

- 14W typical
- 50W during manual operation
- 60W when running heater
- Relay-controlled low voltage disconnect (typically no fires to monitor in winter)

### Ubiquiti Airfiber 5XHD radio

- 12W
- Commonly 2 radios per site

# What are your biggest challenges relating to power systems?



South Carolina - Solar pathfinder (and tall trees!)

## USGS - NCSN

- Sunshine!
- Trees blocking sunshine
- Some sites only accessible by helicopter in winter

## CERI (NM, ET, AG)

- Deferred maintenance
  - Upgrading old solar systems for robustness

## South Carolina

- Trees keep growing!

## TexNet

- Battery testing

## Montana

- Weather in NW Montana - very PNW
  - Foggy - hard for VSTA
  - Low sunshine for power

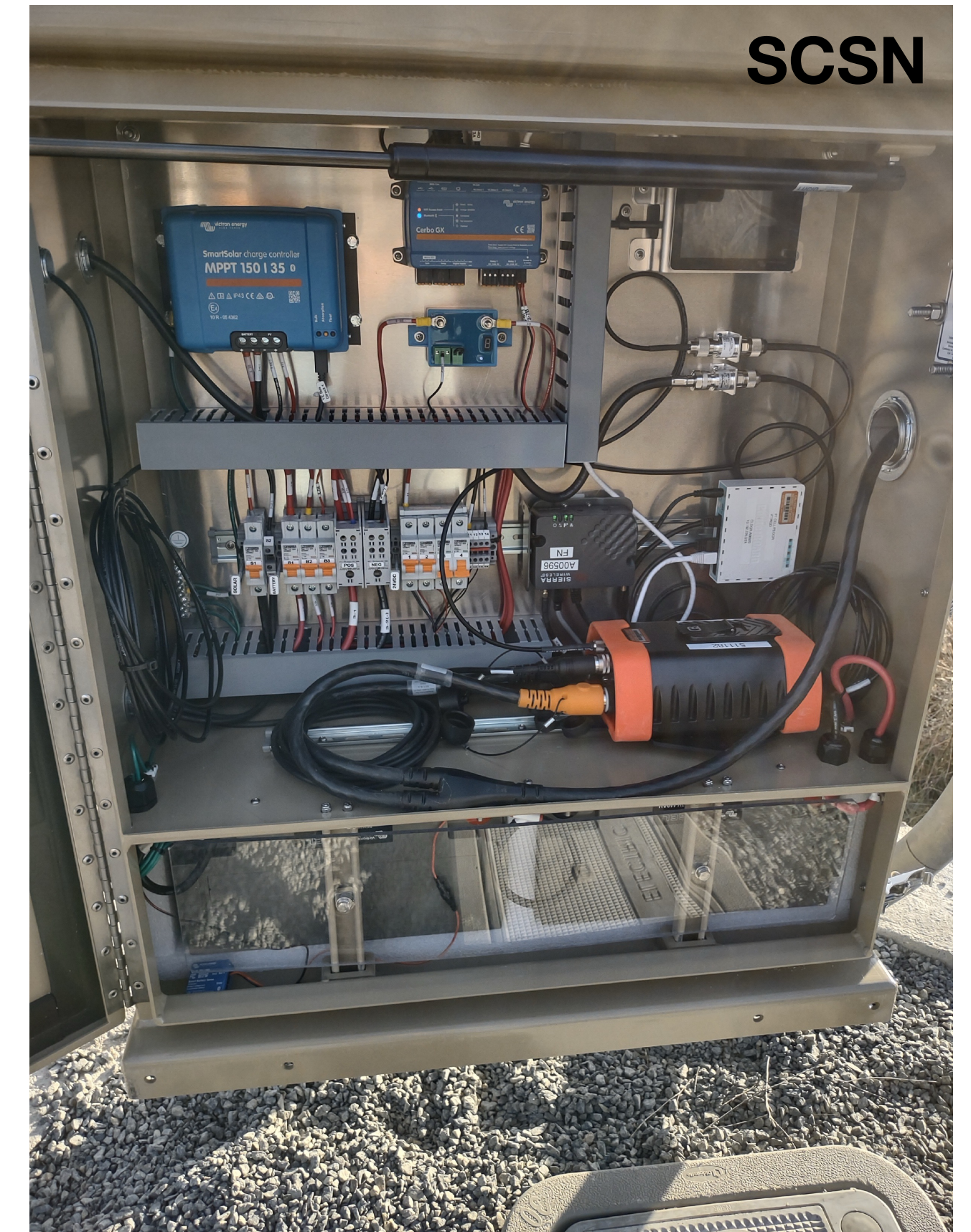
# What are your biggest challenges relating to power systems?

## SCSN

- Using a low voltage disconnect (pros and cons)
  - Pros: Low voltage disconnect protects batteries from a deep discharge if there is a power supply issue at the station.
  - Cons: Often, equipment can run on low voltages. Interrupting load to conserve batteries may result in an earlier offline status for the site.
- Exploring an optimal cut-off threshold for a programmable low voltage disconnect

## Utah

- Backcountry access, strenuous approaches
- Weather
  - Temp impacts battery
  - Snow - buries stuff, cover panels
  - Wind - knocks stuff over
  - Lightning - blow fuses
  - Rain - flooding
- Animals - snack on cables play with equipment



## Nevada

- Backcountry access, strenuous approaches
- Weather (see Utah box)

# CVO Power Systems

- Most issues are climate-related
  - Snow depths exceed 10ft for weeks to months in some areas
  - Rime Ice
  - High winds causing solar panel blow-outs or abrasion
  - Temperatures too low for LiFePO battery charging
- Biggest consumers: radios, GNSS receivers



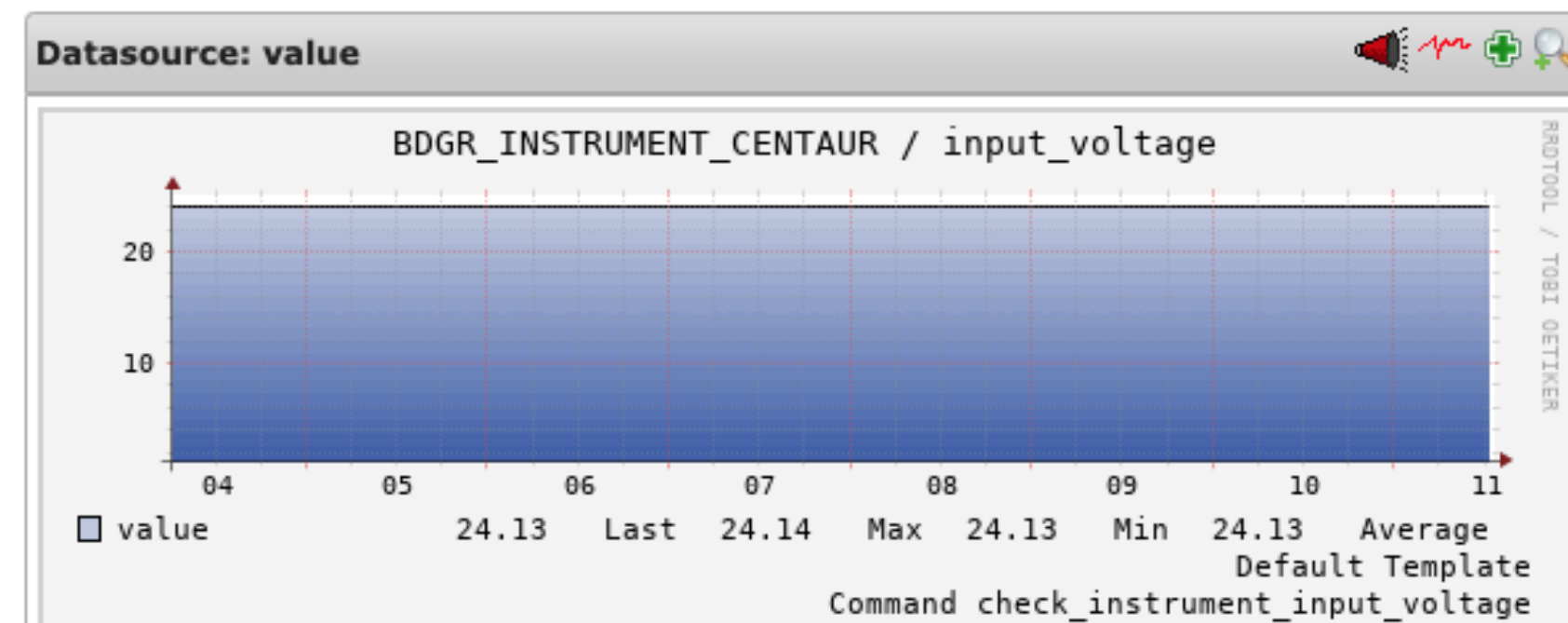
# Power System Challenges

Seismic analysts observed diurnal power fluctuations in long period seismic data with Centaur loggers. Installed 9-36V-in/24V-out voltage converters to stabilize the voltage.

- The unintended consequences of this is that the VEC (voltage in) channel on the Centaur just records a (mostly) flat line. So we have no 1-sps record of system voltage. Cell modems, radios, etc are used to monitor.

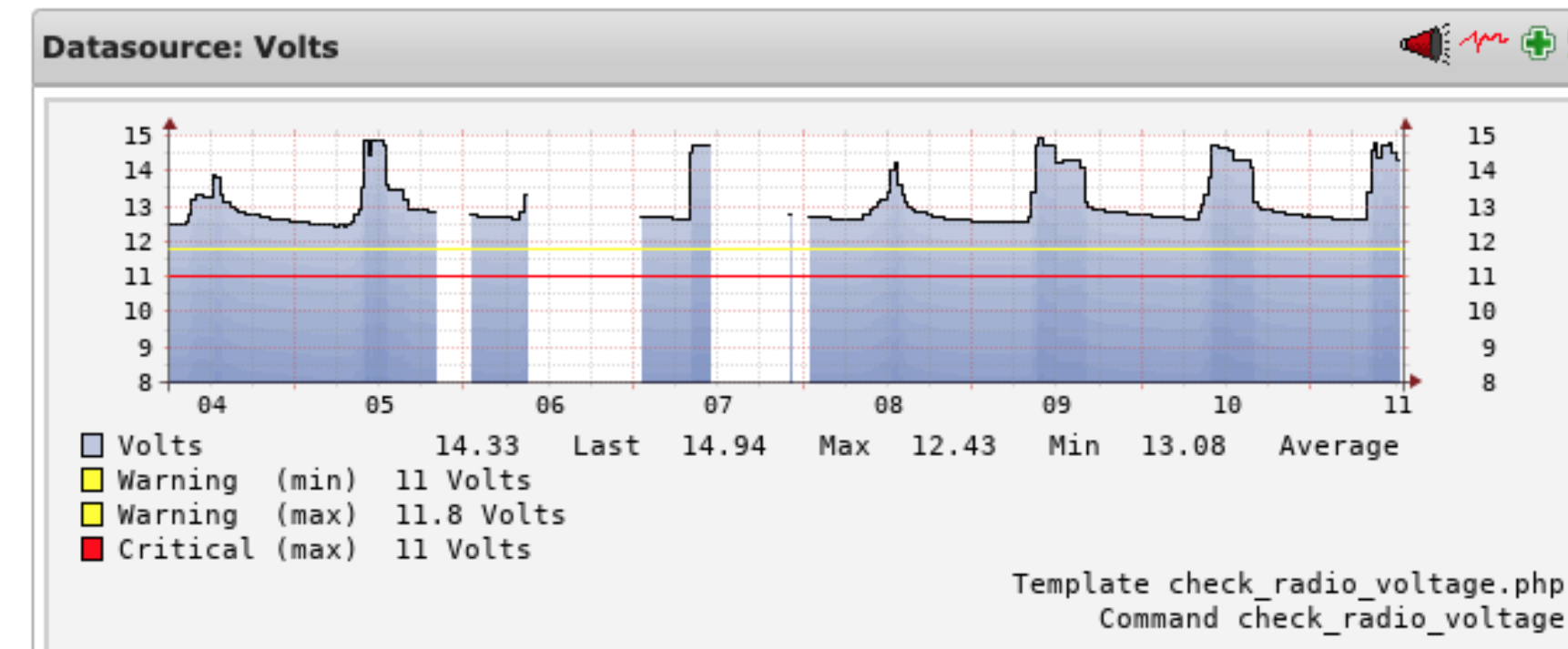
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One Week 2024-01-04 06:00 - 2024-01-11 13:00

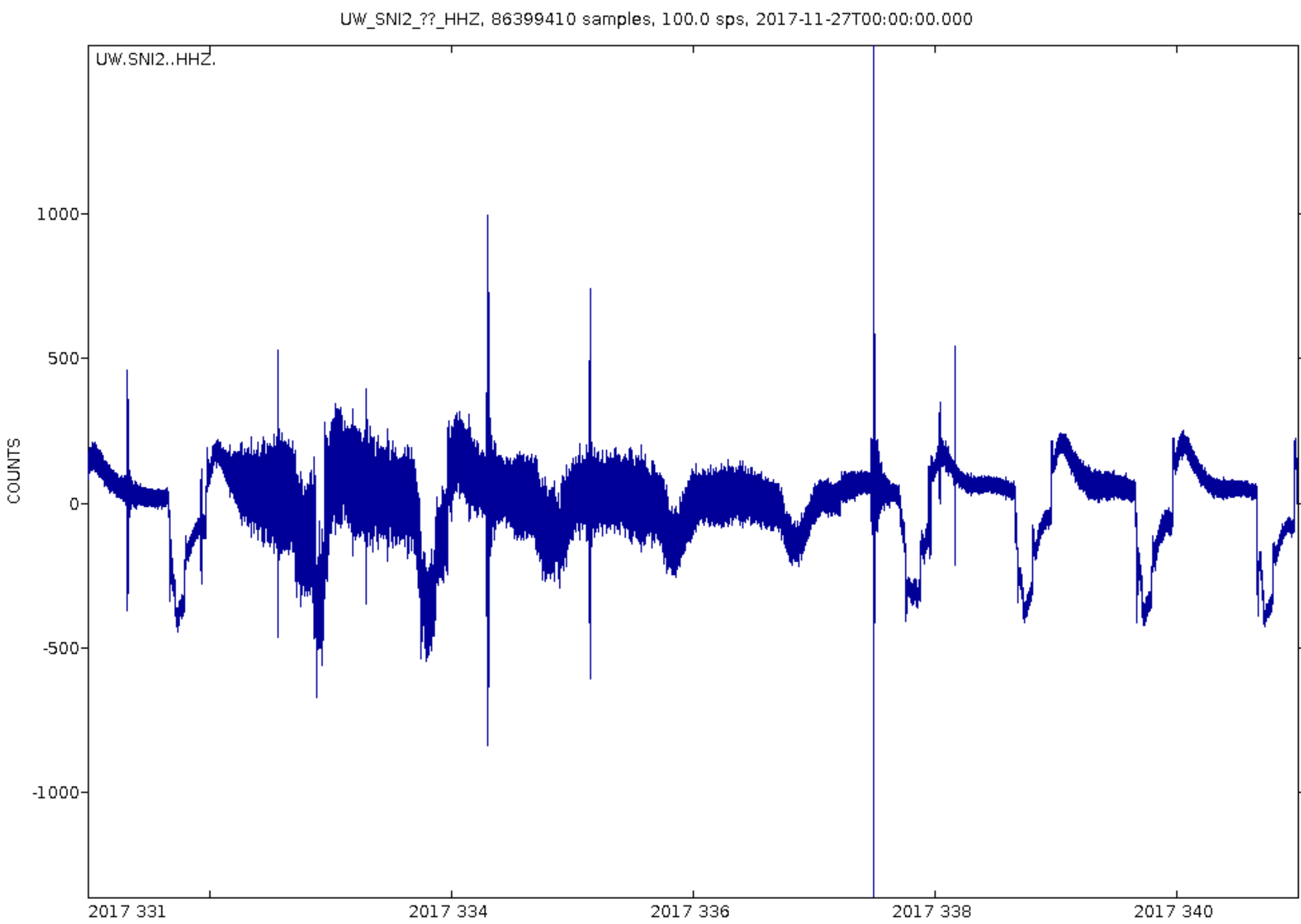


Host: BDGR\_ENDPOINT\_XETA9 Service: volts

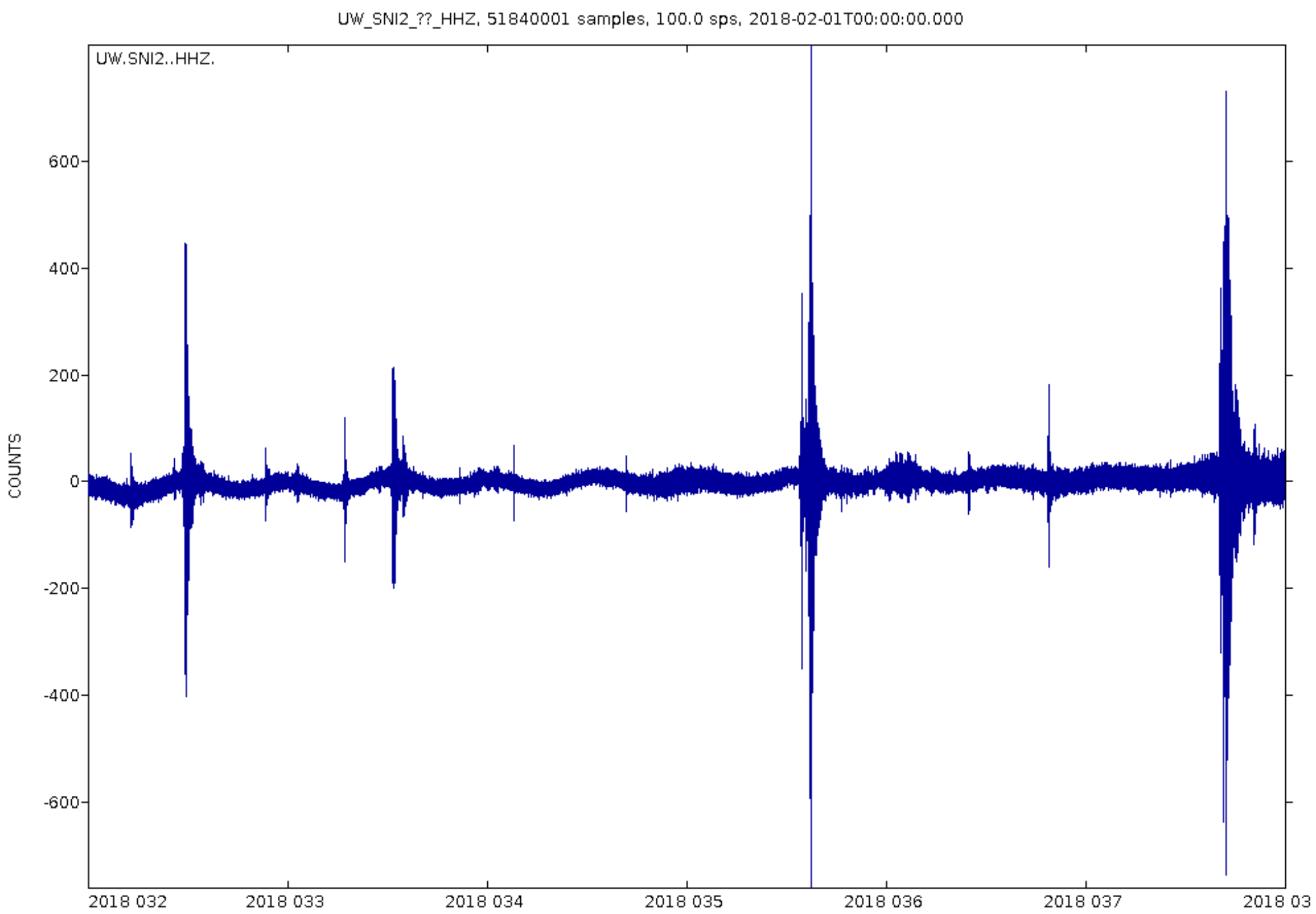
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# Power System Challenges



Before



After



## Power-Related Challenges

- Reconciling various site designs:
  - ShakeAlert sites utilize simplistic design for resilience.
  - Wildfire monitoring sites have higher wattage & varied voltage needs.
- Evolving site designs:
  - More sensors & new tech for multi-hazard monitoring.
- Future challenge will be calibrating “service technician” type position and R&D engineer type position (currently in early stages).

# How do you monitor the SOH of your power systems?

## Utah

- Doesn't stream SOH
- But can check SOH remotely through loggers

## TexNet

- Remote: Continuous voltage monitoring and storage
- Local - 30 day review of MPPT (Maximum Power Point Tracking) data

## Montana

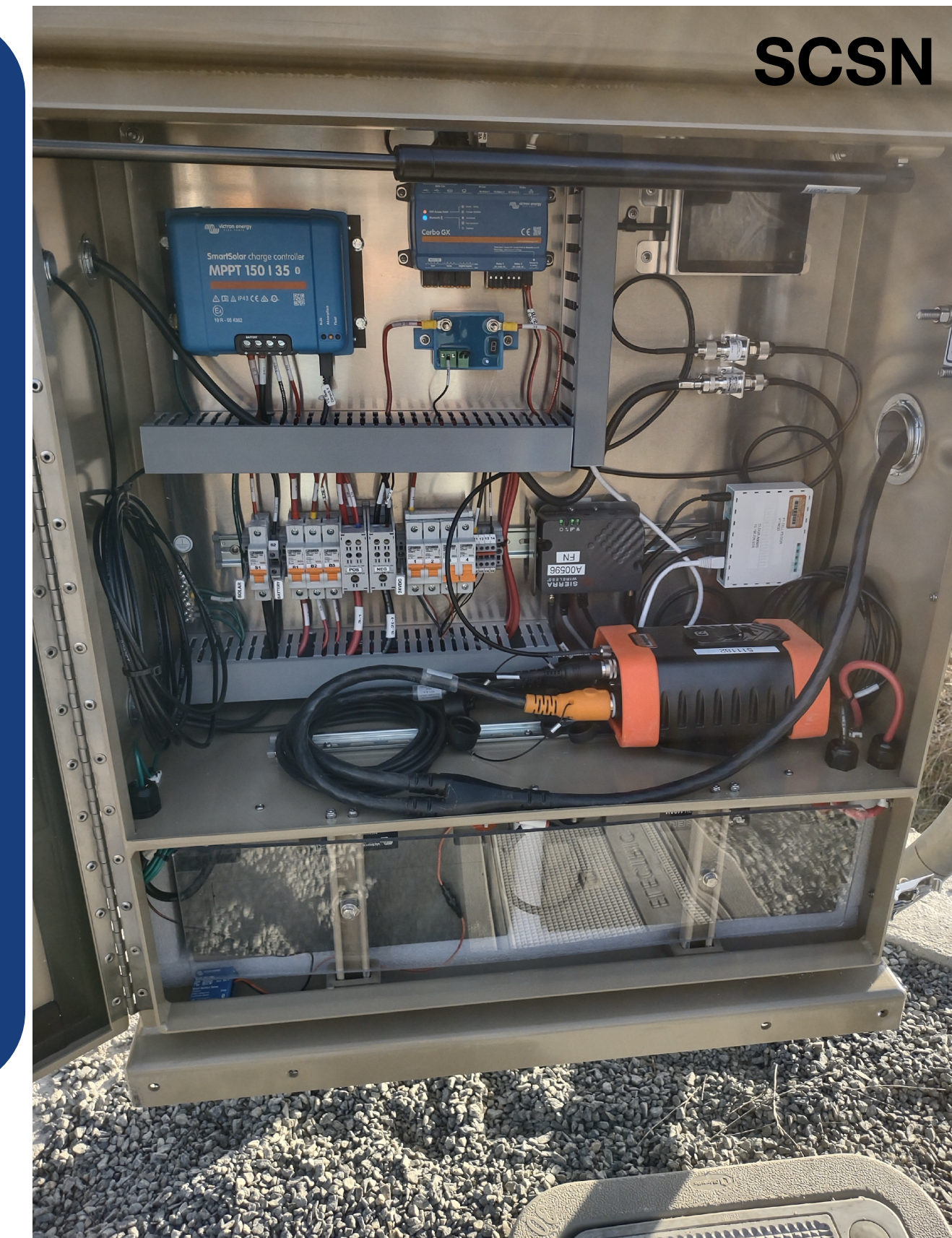
- Watch battery voltage via datalogger when comms are functional

## South Carolina

- Reverse engineered the Bluetooth protocol on the KiloVault batter to get percent charge every 15min

## SCSN

- System SOH channels from catalogers
- Interfaces like AirVantage for Sierra Wireless (cell modems)
- Victron for Victron Energy products (charge controllers, AC-chargers)



# How do you monitor the SOH of your power systems?

## USGS - NCSN

- SeisNetWatch
  - Power on Radios and Dataloggers
- Also monitors:
  - Radio signal health
  - Mass positions
  - Data logger temp
  - Packet loss
  - Latency

## Nevada

- Nagios - real time with alerts
  - Battery temps
  - Battery voltages
  - Latency
  - Packet loss
  - Total data return
- Remote access to data loggers

## CERI (NM, ET, AG)

- Can monitor power SOH with Victron Cerbo GX
- Victron SmartSolar regulators have Bluetooth - you can monitor, configure and save the system status when at the site but not remotely



CERI: Victron SmartSolar regulator system

# Are you trying anything new or unique for power systems?

## USGS - NCSN

- Thermoelectric Power Generators (TEG) as continuous power source for backup batteries
- Ordering the solar hybrid model to use TEG as backup generators
  - Can switch from solar to TEG on low sun days



USGS - NCSN: TEG

## Utah

- Backup Air Cell batteries at very remote sites in Yellowstone

## Montana

- Experimenting with TCp/IP voltmeter via TingSpeak to monitor VSTA batter bank

## Nevada

- GenStar 100 amp charge controller
- CBW - Control by web
  - Allows us to turn of components on the site remotely to have less power usage

## South Carolina

- KiloVault hack
  - manufacturer wont provide spec on packets, but we found the percent charge value

# Are you trying anything new or unique for power systems?

## TexNet

- Using the - 30 day review of MPPT (Maximum Power Point Tracking) data

## SCSN

- Most recent installations, have the Victron remote management system to track power generation and use.
  - Features: user-friendly graphical interface and configurable alarms.

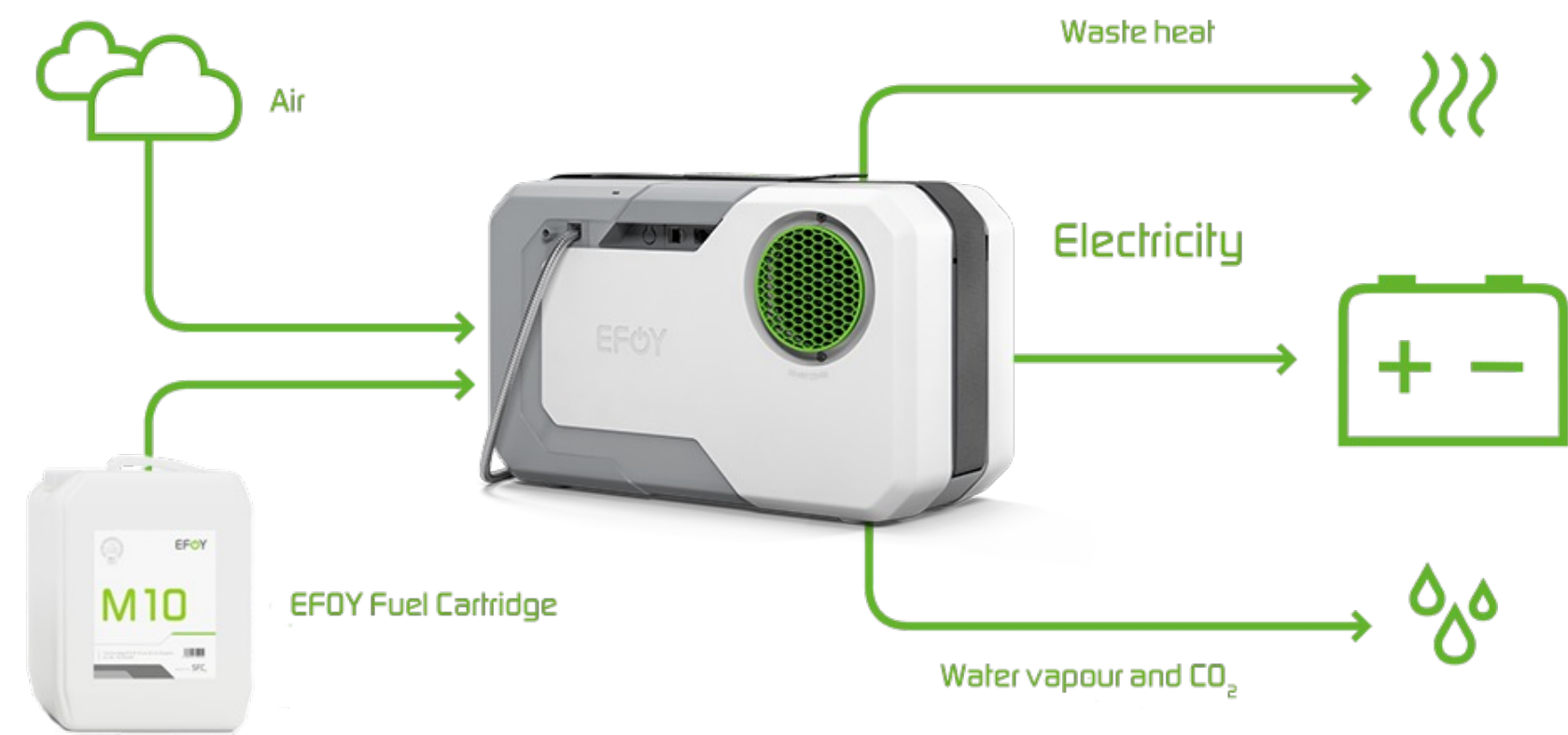


CERI - NM: 167Ft Tower at repeater site

## CERI (NM, ET, AG)

- Added a solar/battery/inverter backup system to an AC powered telemetry NM repeater site.
  - Had solar and battery backup several extended outages recently due to ice, wind and tree fall damage to the power lines
- 167 ft tower site is a microwave and analog telemetry repeater with links to multiple data collection nodes.
- Now have a 3000 W inverter system with 1080 W of solar and 600 AHr of battery backup for an approx. 200 W of load
- Should be good 24/7/365!!!

# New Power System - Efoy



- Appears to provide about 70W in real application
- Enough to carry the load and save batteries from overly deep discharge

