Powering ITS Devices in Challenging Environments

Western States Forum – June 17, 2026

Tyson Larson, JA, UDOT Region Four

Troy C. Torgersen, P.E., UDOT Region Four

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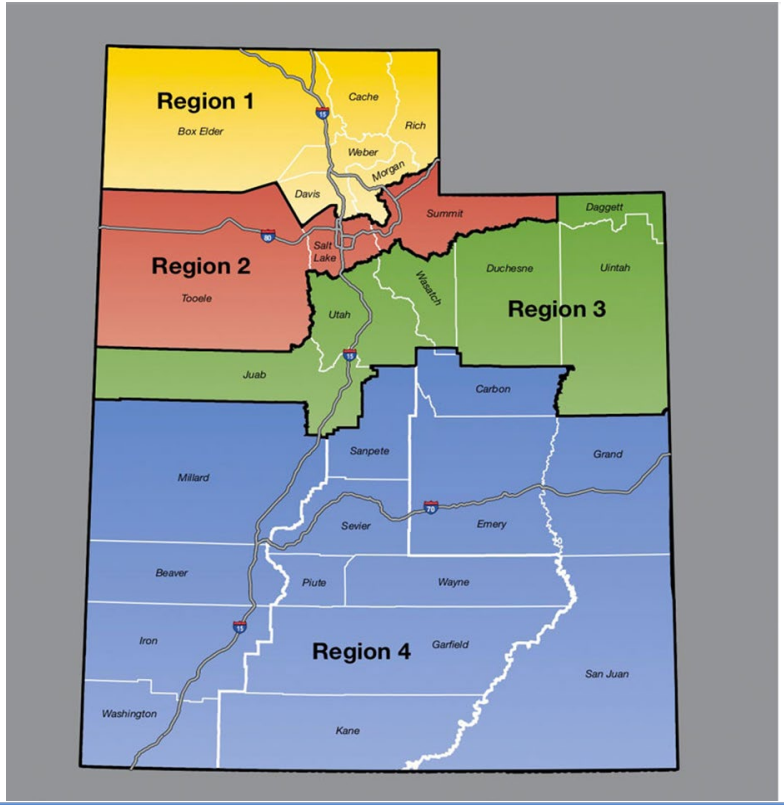
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UDOT Regions



Region 4's CCTV Camera History

Pine Creek Project Design Details

- Days of Autonomy Requirements
  - Size and number of batteries to run 120V AC Equipment
  - 72-hour continuous loading using 100% of the loads
  - Assume batteries are fully charged at start
  - Draw down to 50% of the total battery capacity
    - Daily drawdown of only 20%

Pine Creek Calculated Loads

Electrical Loads Per ATMS Locations		
Case #	Load Per Site	Connected Devices
1	224 Watt Solar Power Source	1 Camera, 1 NID, 1 VSL Sign
2	167 Watt Solar Power Source	1 Camera, 1 NID, 1 Radio
3	164 Watt Solar Power Source	1 Camera, 2 NID
4	152 Watt Solar Power Source	1 Camera, 1 NID
5	176 Watt Solar Power Source	1 Camera, 1 NID, 1 RWIS
6	228 Watt Solar Power Source	1 Camera, 1 NID, 1 Radio, 1 VSL Sign

Calculated Days of Autonomy

Pine Creek Calculated Days of Autonomy 16-12V batteries in (4S4P) 48V System 50% Depth of Discharge			
Row	**Variable**	**Calculated Values**	**Units**
A.	Total Daily Load	3,648	Wh/day
B.	Effective Daily Load - 85% Efficiency	4,291.76	Wh/day
C.	Total Energy	49,920	Wh
D.	Usable Energy - 50% DoD	24,960	Wh
E.	Days of Autonomy (Row D / Row B)	5.82	Days
F.	Battery Capacity (each battery)	260	Ah
G.	Battery Capacity (Total)	1,040	Ah
H.	Total Load	152	W
I.	System Voltage	48	V
J.	Depth of Discharge	0.50	DoD
K.	System Efficiency	0.85	Eff.

Pine Creek – Battery Details

- Battery - AGM
  - Brand: FULLRIVER
  - Model: DC260
  - Amp Hours: 260 Ah
  - Voltage: 12 V
  - Weight: 172 lb
  - Op. Temp: 5° - 122°F



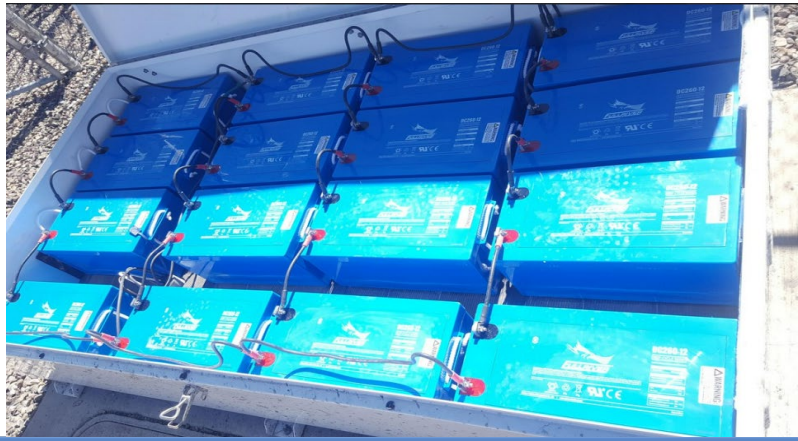


Original Battery Design

- Original Series-Parallel System
  - 16 – 12 Volt Batteries (2S8P)
  - 24 Volt System
  - 260 Ah x 8 = 2,080 Ah

Actual Battery Setup

- Series-Parallel (4S4P)
  - 16 – 12 Volt Batteries
  - 48 Volt System
  - 260 Ah x 4 = 1,040 Ah



Solar System Equipment

- Solar System Components
  - ExelTech XP600 48 Volt Sine Wave Inverter
  - Midnite Model Classic 200 Solar Controller
  - 9 - Solar World Mono 285 W Panels



Pine Creek 3-day Autonomy Test

Pine Creek - 3 Day Autonomy Test						
Measurements Taken 10/26/2015				Measurements Taken 10/29/2015		
Location	Time	Battery Voltage (DC)	Inverter Voltage (AC)	Time	Battery Voltage (DC)	Inverter Voltage (AC)
SB MP125.5 - RWIS	12:25	54.70	118.00	12:30	51.40	118.6
SB MP123	12:45	52.70	117.70	13:15	49.90	118.30
NB MP122	13:15	54.60	118.10	13:45	49.70	118.60
NB MP125	13:45	52.70	116.30	14:15	49.70	116.80

Calculated vs. Actual Performance

- Calculated autonomy
  - 5.82 days
- Autonomy based on actual load
  - 24 days @ 77 degrees F
- Autonomy in the summer
  - 30+ days
- Autonomy in winter
  - ?
- Fire took out solar system
  - Equipment Ran for over 30 days



Various Solar Project Layouts





Various Solar Project Layouts





LiveView Replacement Project

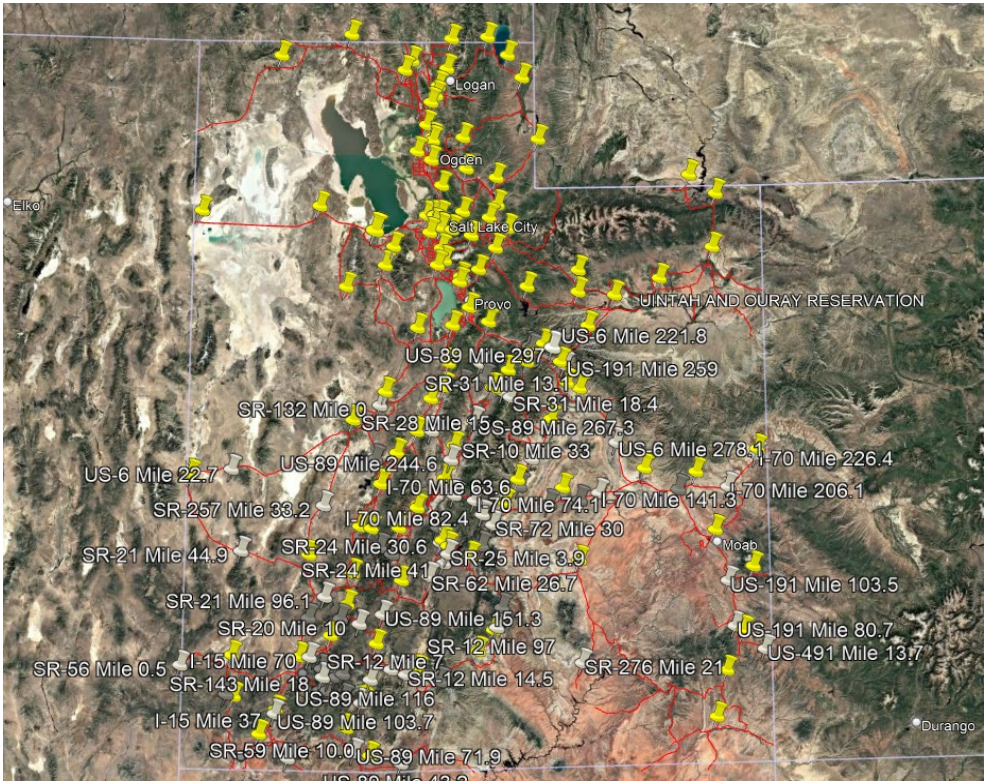
LiveView's Installations Types







Statewide Camera Locations



LiveView Project Details

- A company provided CCTV Camera Service
- 173 CCTV Camera Sites Statewide
- Cameras were not meeting needs of State
- Legislative Funding – One time block fund
- Initial Project Scope developed by a consultant
- Each Region to oversee their project
- Initial approved Project amount $2M

LiveView Project Cont.

- UDOT Research for new system
- Consultants hired to put projects together
- Coordination on Projects Statewide
- Updated Estimates for System
- UDOT Maintenance to fund any pad work

LiveView Initial Design Criteria

- Loads need to be divided between continuous and non-continuous
  - This allows us to calculate both the size of the solar array and the battery bank.
- First, 72 to 96 hours of autonomy within the system.
- Second, battery bank to be completely recharged in 3 to 4 hours.
- Most storms last about three to four days.
- These sites are placed in the same areas the remote cameras are currently placed.
- Default to AC where possible however AC is not always available.

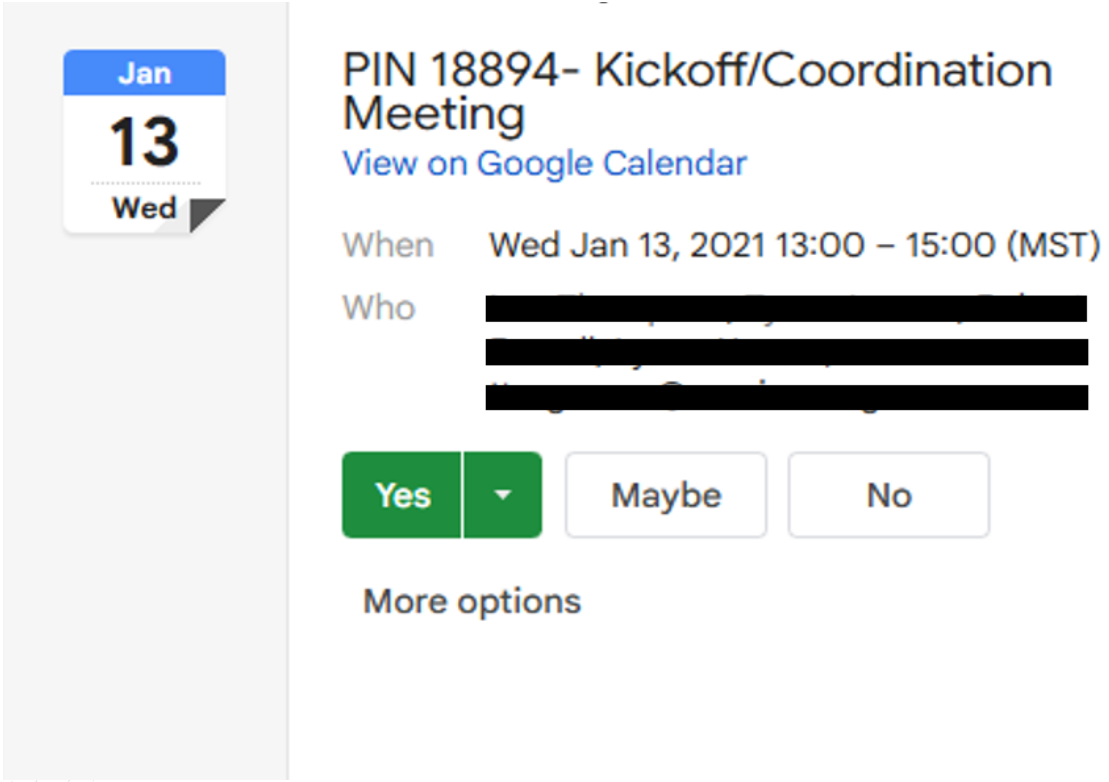
Design Criteria Cont.

- Assume 24 VDC system
- 12 hours of camera usage per day
- Use of a fiber switch or,
- Use of a modem

Communication Options

- Coordinate with **TMD** when using radios and Utah Communication Authority (UCA) towers
- Priority for communications connections:
  - Fiber (UDOT)
  - CDMA/Cell Modem
  - Fiber (Telco)
  - Radio/UCA

Kick-off/Coordination Meeting

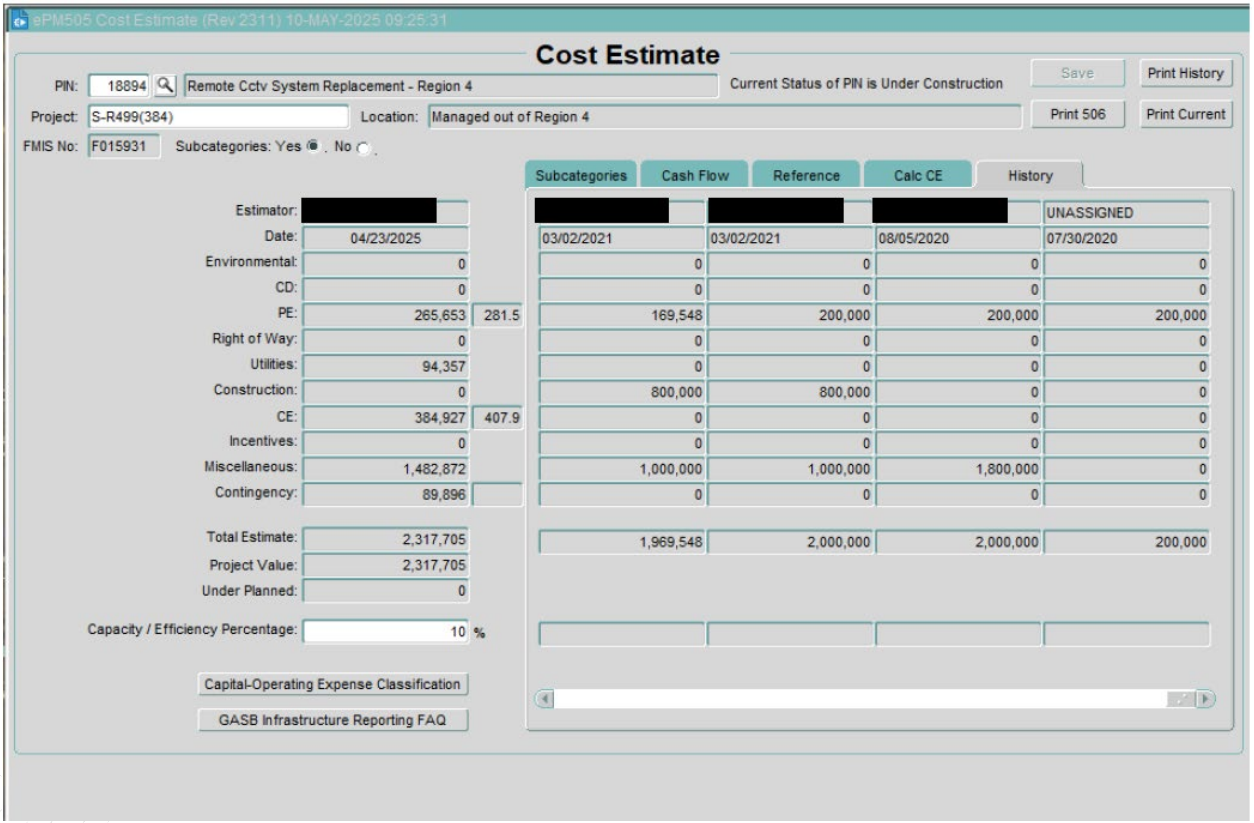


Design Services Contract

Design Engineering Services support – Remote CCTV Camera System Replacement - $2,250 per site:

- Design plans for up to 75 sites for Region 4
- UDOT Maintenance Station Supervisors coordination
- 6-7 site plans will be delivered at a time for advertisement.
- Plan-in-Hand and PS&E Reviews not required

Project Cost Estimate



Cabinet Types Discussed

- UDOT 334



- UDOT 336



Cabinet Types Cont.

- UDOT CCS/TMS



- UDOT LiveView



CCTV Camera Pole Types





Solar Panel Selected

Solar Controllers & Accessories (NON-STOCK)

Description	Commodity Code
PV Modules / 320W / LR6-60HPB-320M	NONSTOCK404



Category	Solar Controllers & Accessories (NON-STOCK)
Model #	LR6-60HPB-320M
Unit Price	$234
Compatible with...	
Notes	320W Solar Panel. 66.2 in H x 39.2 in W x 1.4 in T. Need 2 for a 2-Panel Solar Site and 4 for a 4-Panel Solar Site.

Lead Time:	8 weeks	Vendor:	Steadfast Solar
Desired Stock:	0	Contract:	219522
Reorder Threshold:	0	Contract Expiration Date:	October 31, 2025
Spec Sheet:	https://s3.amazonaws.com/ecodirect_docs/LONGi/LONGi-LR6-60HPB-305M-datasheet.pdf		

Battery Design Details

- Battery: NorthStar NSB 190FT Blue
  - Long Design Life
    - 12 yrs @ 68°F
    - 2,050 Cycles
  - Operating Temp
    - -40°F to +149°F
  - Ultra-fast Recharge
  - Shelf life up to 24 month
  - Weight 132 lb



Battery Design Details Cont.





	NSB 190FT BLUE+	NSB 210FT BLUE+
Height	12.4 in (316 mm)	12.9 in (328 mm))
Width	4.9 in (125 mm)	4.96 in (126 mm)
Length	22.1 in (561 mm)	22.0 in (560 mm)
Weight	132 lbs (60 kg)	139 lbs (63 kg)
Terminal	Male M6	Male M6
Terminal Torque	9.0 Nm (81 in-lbs)	9.0 Nm (80 in-lbs)
10 hr Capacity to 1.80VPC @ 25°C (77°F)	183 Ah	200 Ah
8 hr Capacity to 1.75VPC @ 25°C (77°F)	180 Ah	198 Ah
Float Voltage at 20°C (68°F) / 25°C (77°F)	2.28 / 2.27 VPC	2.28 / 2.27 VPC
Impedance (1kHz)	3.3	3.3
Short Circuit Current	3990 A	3800 A
Maximum Charge Current	No Limit	No Limit
Nominal Voltage	12 V	12 V

Solar Controller Used



Relay Driver Used

RELAY DRIVER™

Logic Module Accessory

Installation, Operation and Maintenance Manual



Four-Channel Relay Driver

MORNINGSTAR
World's Leading Solar Controllers & Inverters

www.morningstarcorp.com

Project CCTV Cameras

Axis Q6135-LE PTZ Camera

AXIS COMMUNICATIONS

AXIS Q6135-LE PTZ Network Camera

High-speed PTZ with long-range optimizedIR

AXIS Q6135-LE offers HDTV 1080p with 32x optical zoom. It features OptimizedIR up to 250 m (820 ft) or more depending on the scene and Lightfinder 2.0 for clear, sharp images even in challenging light. Sharpdome technology allows you to see 20° above the horizon with the same sharp image quality as below. It includes orientation aid and autotracking 2 with click and track functionality. Privacy masking with mosaic lets you pixelate whole areas of the scene. It includes enhanced security features such as signed firmware, secure boot and TPM module. Plus, Axis Zipstream with support for H.264 and H.265.

> HDTV 1080p with 32x optical zoom
> OptimizedIR (250 m/820 ft range)
> Lightfinder 2.0
> Autotracking 2 and orientation aid
> TPM, FIPS 140-2 level 2 certified



- Typical 10.3 W
- Max 51 W (Stated)

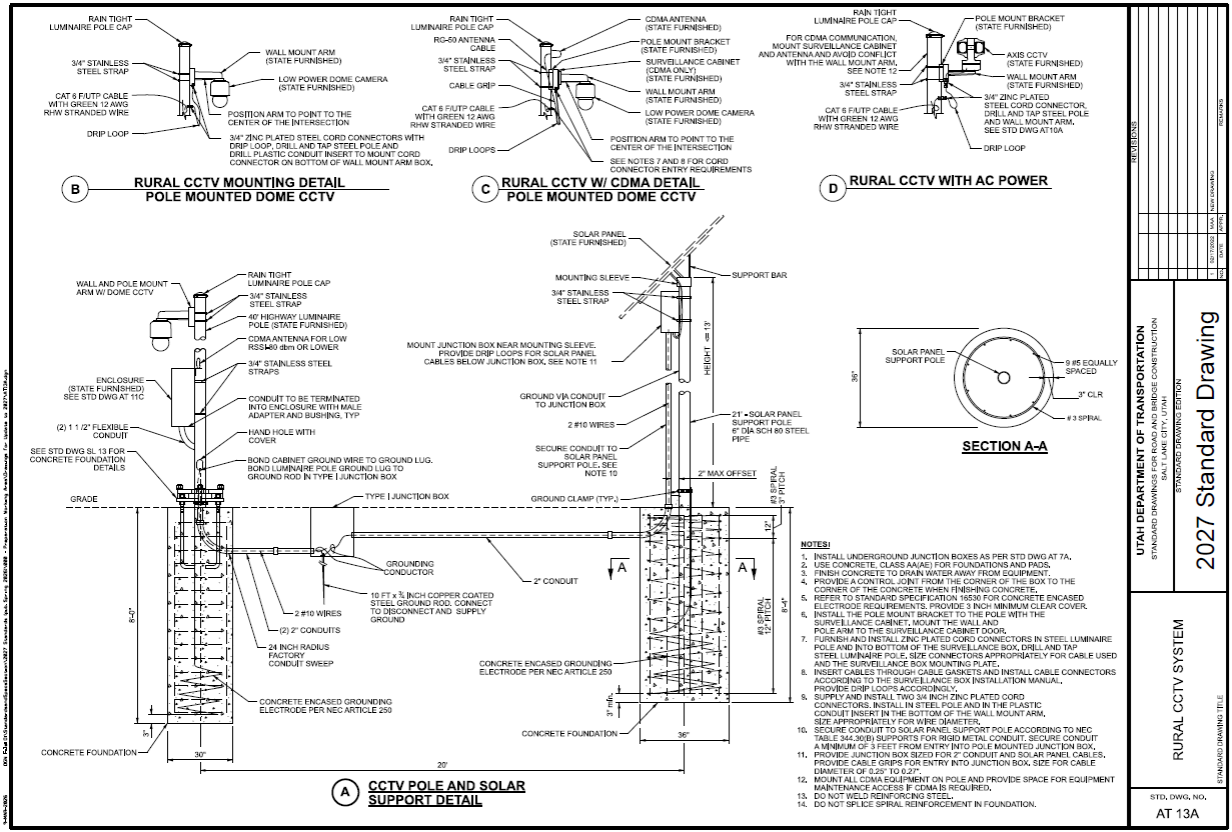
Axis Q6215-LE PTZ Camera

Axis Q6215 (Q6225)

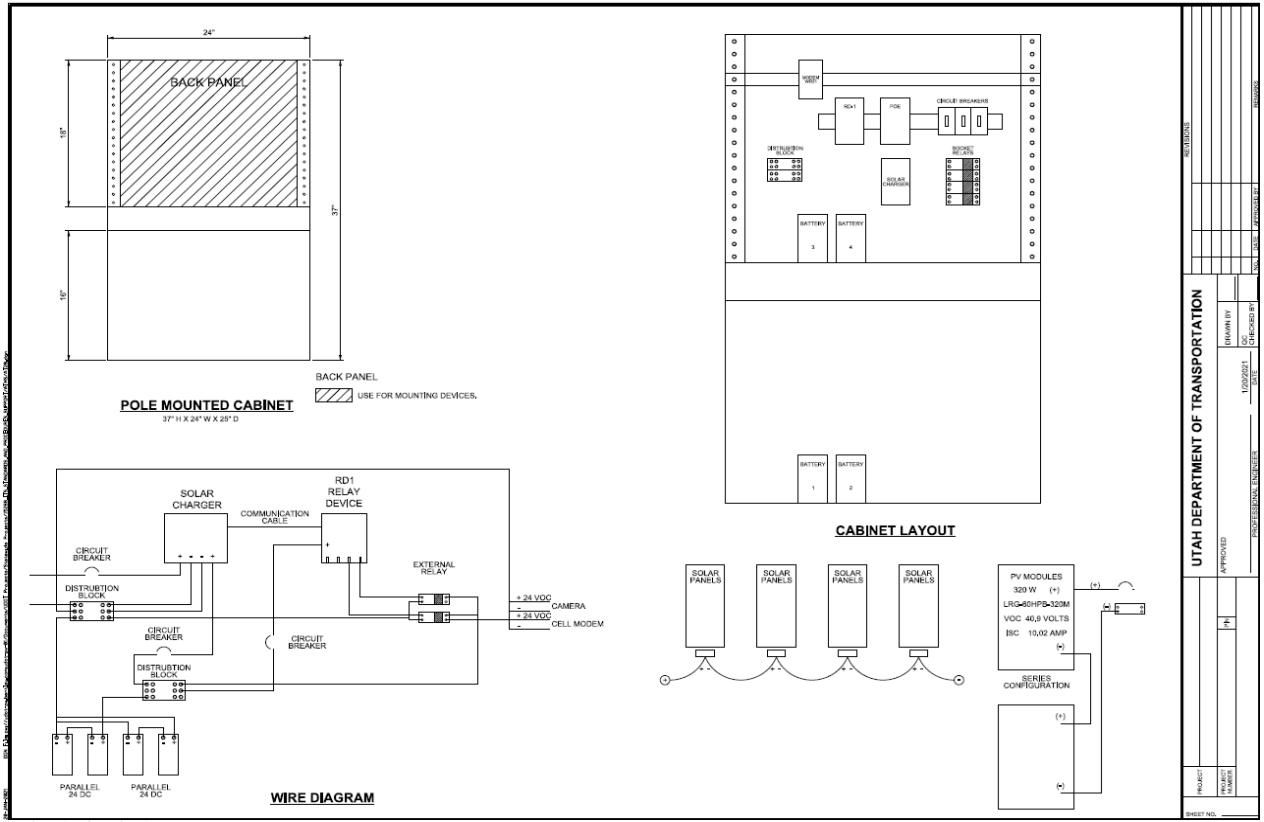
- Typical 25 W
- Max 71 W



CCTV Camera System Layout

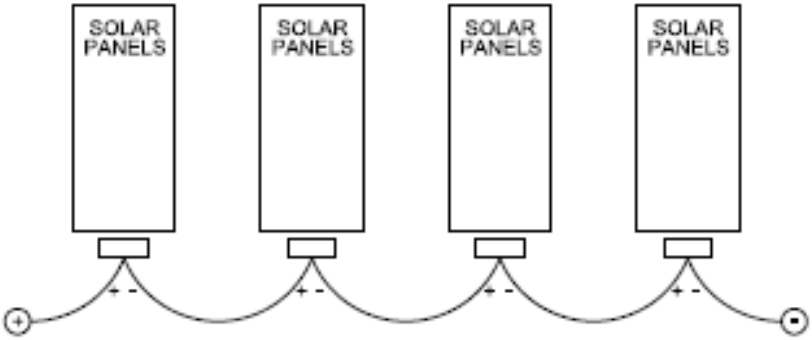


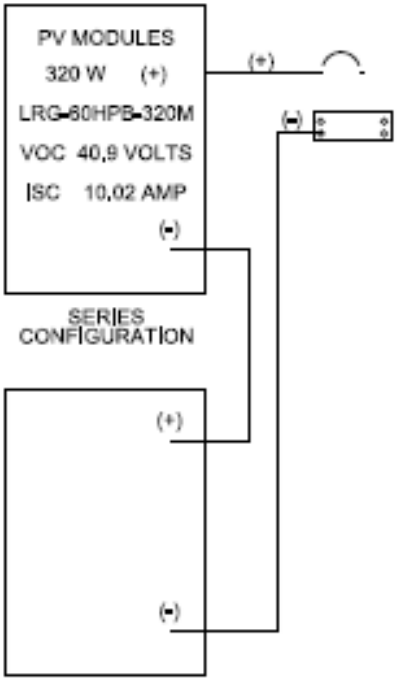
Initial Cabinet Layout



2026 Standard Drawing

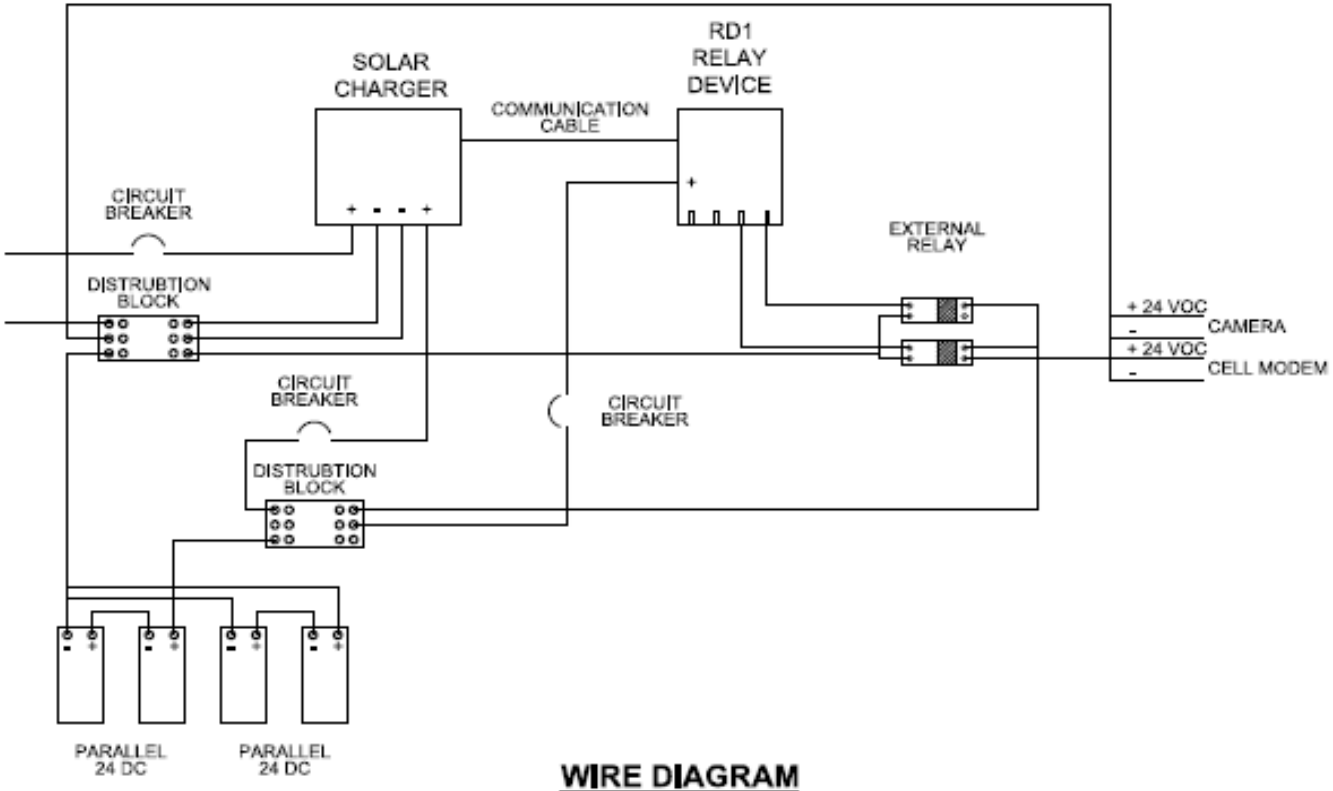
Initial Solar Panel Wiring





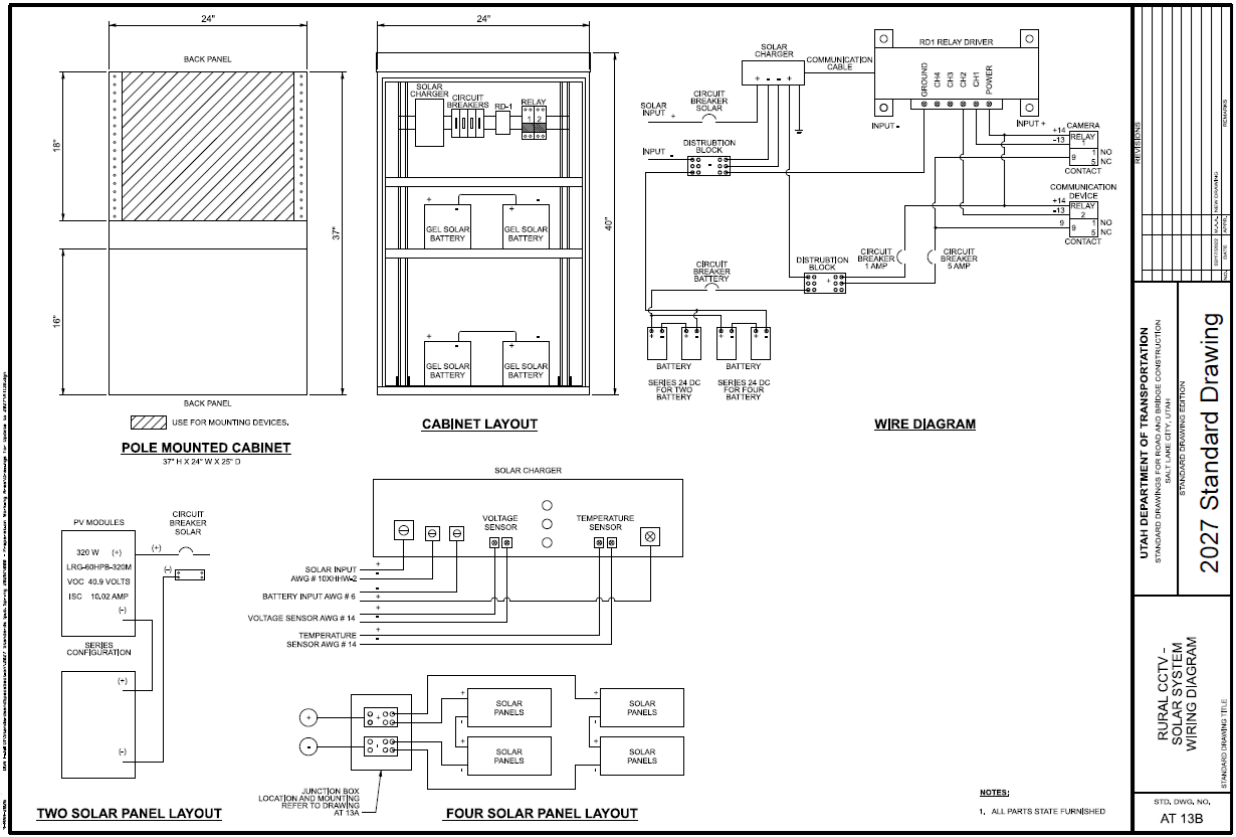
2020 Standard Drawing

Relay Driver Layout

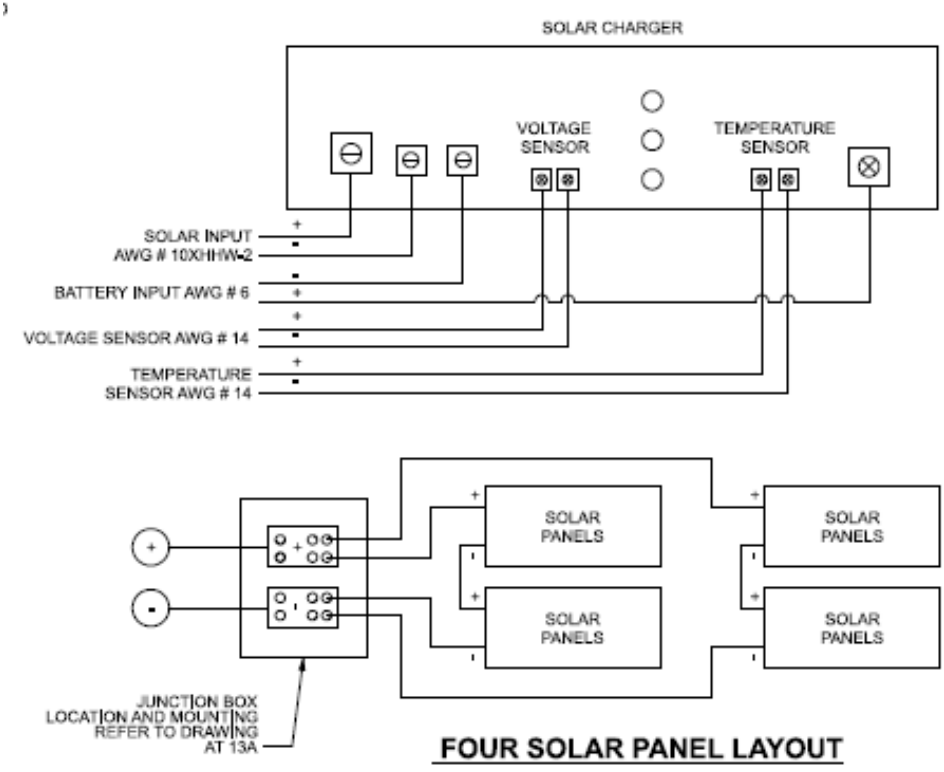


WIRE DIAGRAM

Final Cabinet Layout



Updated Solar Panel Wiring



Relay Driver Settings

1.3 Factory Settings

The Relay Driver is pre-configured at the factory with a default configuration as outlined below. If a different configuration is needed, a custom configuration will need to be programmed into the Relay Driver. ***Sections 2.0 through 5.0 explain software installation, custom configuration, and installation.***

Channel 1
Threshold Function:
- Channel OFF when $V_{battery}$ < 11.5V
- Channel ON when $V_{battery}$ > 12.6V
- 1 minute delay before turning on/off

Channel 2
Threshold Function:
- Channel OFF when $V_{battery}$ < 11.1V
- Channel ON when $V_{battery}$ > 12.2V
- 1 minute delay before turning on/off

Channel 3
Threshold Function:
- Channel OFF when $V_{battery}$ < 14.0V
- Channel ON when $V_{battery}$ > 15.0V

Channel 4
TriStar Alarm/Fault Monitor:
- Channel OFF when no alarms/faults exist
- Channel ON when any alarms/faults exist
- Excludes RTS open alarm
- No communication time-out alarm

Project Relay Driver 24 Volt System

1.3 Factory Settings

The Relay Driver is pre-configured at the factory with a default configuration as outlined below. If a different configuration is needed, a custom configuration will need to be programmed into the Relay Driver. ***Sections 2.0 through 5.0 explain software installation, custom configuration, and installation.***

Channel 1 - Camera
Threshold Function:
- Channel OFF when $V_{battery}$ < 23.0V
- Channel ON when $V_{battery}$ > 25.2V
- minute delay before turning on/off

Channel 2 - Communication Device
Threshold Function:
- Channel OFF when $V_{battery}$ < 22.2V
- Channel ON when $V_{battery}$ > 24.4V
- 1-minute delay before turning on/off

Channel 3
Threshold Function:
- Channel OFF when $V_{battery}$ < 14.0V
- Channel ON when $V_{battery}$ > 15.0V

Channel 4
TriStar Alarm/Fault Monitor:
- Channel OFF when no alarms/faults exist
- Channel ON when any alarms/faults exist
- Excludes RTS open alarm
- No communication time-out alarm

2026 Standard Drawing

Project Relay Driver 48 Volt System

1.3 Factory Settings

The Relay Driver is pre-configured at the factory with a default configuration as outlined below. If a different configuration is needed, a custom configuration will need to be programmed into the Relay Driver. ***Sections 2.0 through 5.0 explain software installation, custom configuration, and installation.***

Channel 1 - Camera
Threshold Function:
- Channel OFF when $V_{battery}$ < 46.0V
- Channel ON when $V_{battery}$ > 50.4V
- minute delay before turning on/off

Channel 2 - Communication Device
Threshold Function:
- Channel OFF when $V_{battery}$ < 44.4V
- Channel ON when $V_{battery}$ > 48.8V
- 1-minute delay before turning on/off

Channel 3
Threshold Function:
- Channel OFF when $V_{battery}$ < 14.0V
- Channel ON when $V_{battery}$ > 15.0V

Channel 4
TriStar Alarm/Fault Monitor:
- Channel OFF when no alarms/faults exist
- Channel ON when any alarms/faults exist
- Excludes RTS open alarm
- No communication time-out alarm

2026 Standard Drawing

Definitions Table

Row	Variable	Calculations	Units
A.	Total Daily Load	Total Load x Hours of Load/Day	Wh/day
B.	Effective Daily Load - 85% Efficiency	Total Daily Load / System Efficiency Factor	Wh/day
C.	Total Energy	No. of Batteries x Battery Voltage x Battery Ah Rating	Wh
D.	Usable Energy - 50% DoD	Total Energy x DoD	Wh
E.	Days of Autonomy (Row D / Row B)	Usable Battery Energy / Effective Daily Load	Days
DoD	Depth of Discharge	Lead Acid Battery	0.50
DoD	Depth of Discharge	LiFePO4	0.85
SE	System Efficiency	0.85 to 0.95	0.85

LiveView Solar Site Loads

Device	Watts	Hrs./Day	Wh/Day
Camera (night)	51	12	612
Camera (day)	14	12	168
Midspan Power Supply	1	24	24
Modem	9.8	24	235
Solar Controller	2.7	24	65
		Total	**1,104**

Fiber Switch Communication

Device	Watts	Hrs./Day	Wh/Day
Camera (night)	51	12	612
Camera (day)	14	12	168
Midspan Power Supply	1	24	24
Switch (9.5 W - 15 W)	12	24	288
Solar Controller	2.7	24	65
		Total	**1,157**

LiveView Calculated Days of Autonomy 2-12V batteries - 24V System 50% Depth of Discharge

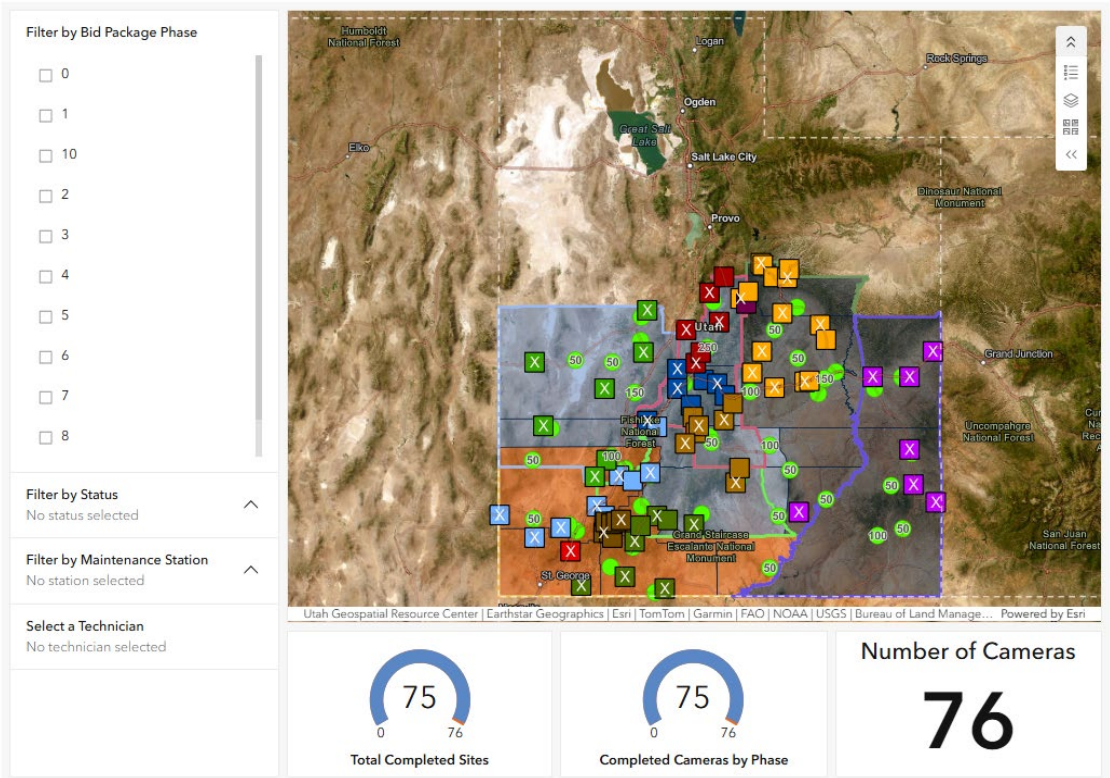
Row	Variable	Calculated Values	Units
A.	Total Daily Load (Wh/day)	1,157	Wh/day
B.	Effective Daily Load - 85% Eff. (Wh/day)	1,361.18	Wh/day
C.	Total Energy (Wh)	4,800	Wh
D.	Usable Energy - 50% DoD (Wh)	2,400	Wh
E.	Days of Autonomy (Row D / Row B)	1.76	Days
F.	Battery Capacity (each battery)	200	Ah
G.	Battery Capacity (Total)	200	Ah
H.	System Voltage	24	V
I.	Depth of Discharge	0.50	DoD
J.	System Efficiency	0.85	Eff.

LiveView Calculated Days of Autonomy 4-12V batteries - 24V System 50% Depth of Discharge

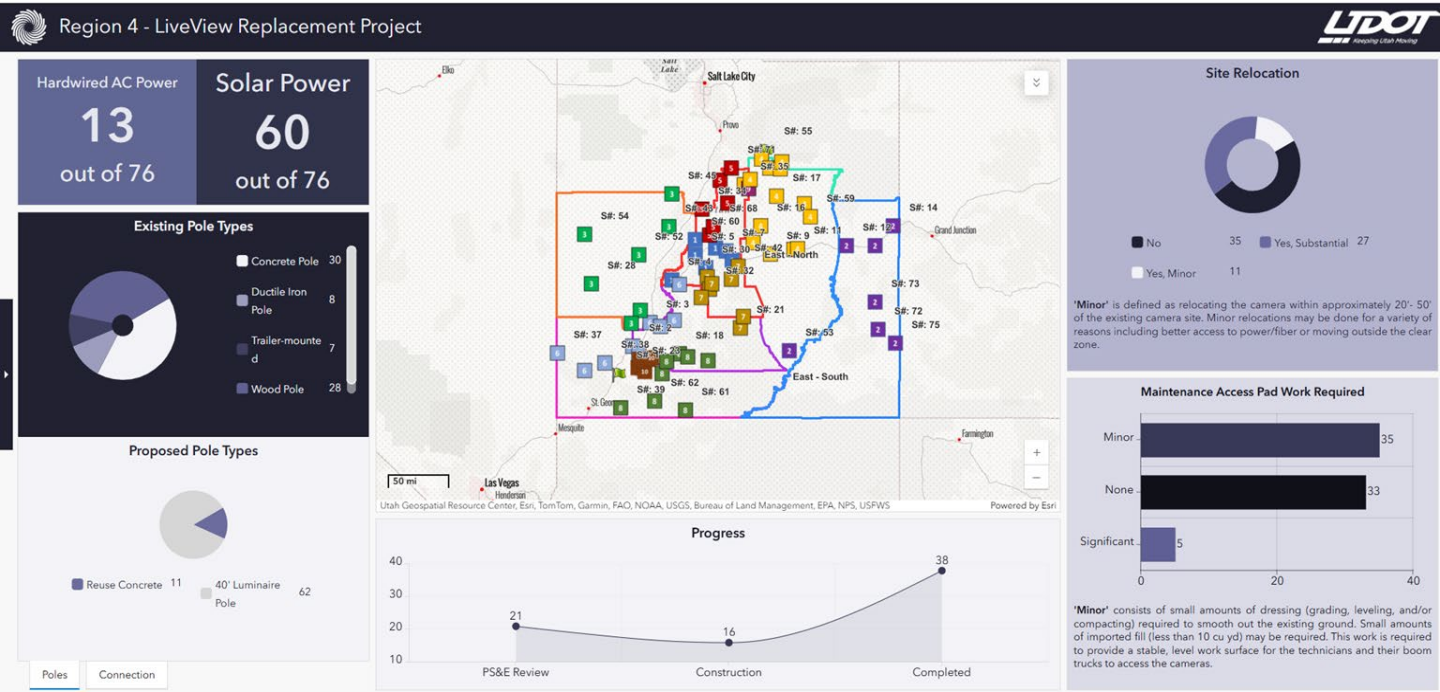
Row	Variable	Calculated Values	Units
A.	Total Daily Load	1,157	Wh/day
B.	Effective Daily Load - 85% Efficiency	1,361.18	Wh/day
C.	Total Energy	9,600	Wh
D.	Usable Energy - 50% DoD	4,800	Wh
E.	Days of Autonomy (Row D / Row B)	3.53	Days
F.	Battery Capacity (each battery)	200	Ah
G.	Battery Capacity (Total)	400	Ah
H.	System Voltage	24	V
I.	Depth of Discharge	0.50	DoD
J.	System Efficiency	0.85	Eff.

R4 CCTV Camera Overview

LiveView Camera Replacement Status



Region 4 CCTV Camera Cont.



Project Documentation Example

Bid Package	Site #	Route	Reference Post	Maintenance Access Pad Work Req'd	Maintenance Access Notes:	General Site Notes:	Maintenance Station
5	34	SR-28	14.953	SIGNIFICANT	Access is good. Will require import (approx. 10 cu yd, potentially more)/grading to build a level/compact pad.	Ex. site appears to be located on RWIS pole. New pole to be placed adjacent to ex. site. Solar power and cellular communications to be used. Minor grading work required to improve maintenance access and provide flatter pad.	4462 - Gunnison
5	46	SR-132	43.735	MINOR	Access from road is okay. Pad needs more leveling/compacting as the ground is very soft.	Ex. camera is trailer mounted. Relocating site ~1500' NW by farm for fiber connection. Requires CCTV and solar pole installs. Requires minor site grading to level and compact maintenance pad.	4461 - Mt Pleasant
5	67	US-89	234.462	NONE	No issues. Flat, easy access. No work req'd.	Reusing exist. concrete pole w/ new solar pole install. No issues with CZ or maintenance access. Trenching to CentraCom fiber splice point approx. 200' south of site. (Nearby power option for future upgrades)	4462 - Gunnison
5	68	US-89	244.589	MINOR	Easy access. Need a larger pad as existing ground is only flat approximately 6' from pole.	Re-using existing concrete pole. Requires solar pole install. Requires minor grading to expand maintenance access pad. Connecting to exist. CentraCom fiber splice point near power pole (within 50').	4462 - Gunnison
5	69	US-89	267.362	NONE	Good pad. Good access. No work req'd.	Exist. wood pole to be replaced with luminaire pole. Using solar and cellular for power and communication connections. (Potential to connect to hardwired power at SE/SW corner of intersection for future upgrades.)	4461 - Mt Pleasant
5	70	US-89	290.116	NONE	Good slope and flat area around pole. Good access from road. No work req'd.	Replacing existing wood pole w/ new CCTV and solar pole installs near exist. site. Solar power and fiber communication to be used. Requires trenching to CentraCom fiber connect along R/W fence (same side of road, within 100').	4461 - Mt Pleasant
5	71	US-89	297.028	NONE	Prop. location on east side of road at edge of existing pullout. Good pad. No work req'd.	Relocating across road to edge of exist. NB pullout (exist. SB pullout site not viable due to CZ/ROW issues). Requires CCTV and solar pole installs. Connecting to CentraCom fiber splice point along east R/W fence (within 50').	4461 - Mt Pleasant

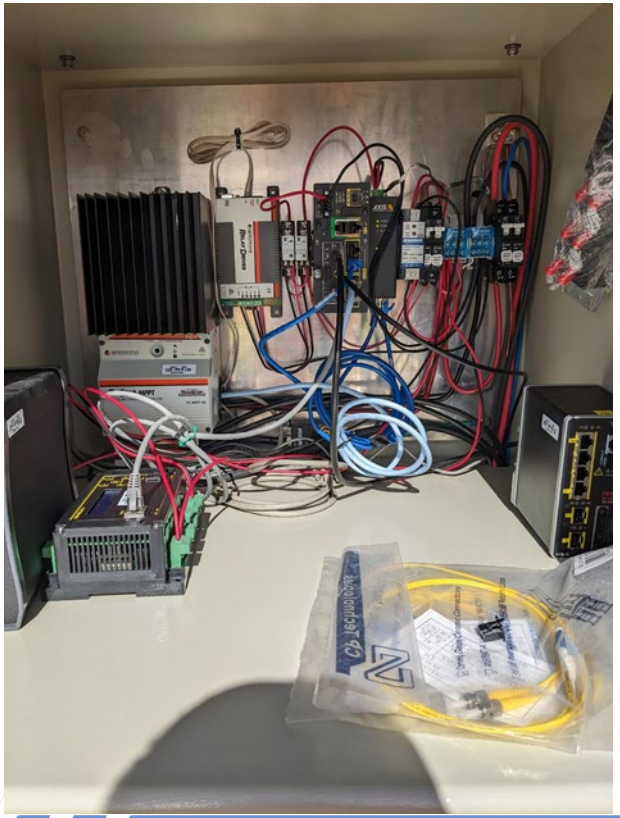
Maintenance Pad Requirements:	14' X 35' level area adjacent to CCTV pole. 20:1 max slope.
Maintenance Access Requirements:	12' wide access road to allow for a bucket truck to exit the road and reach the parking pad.

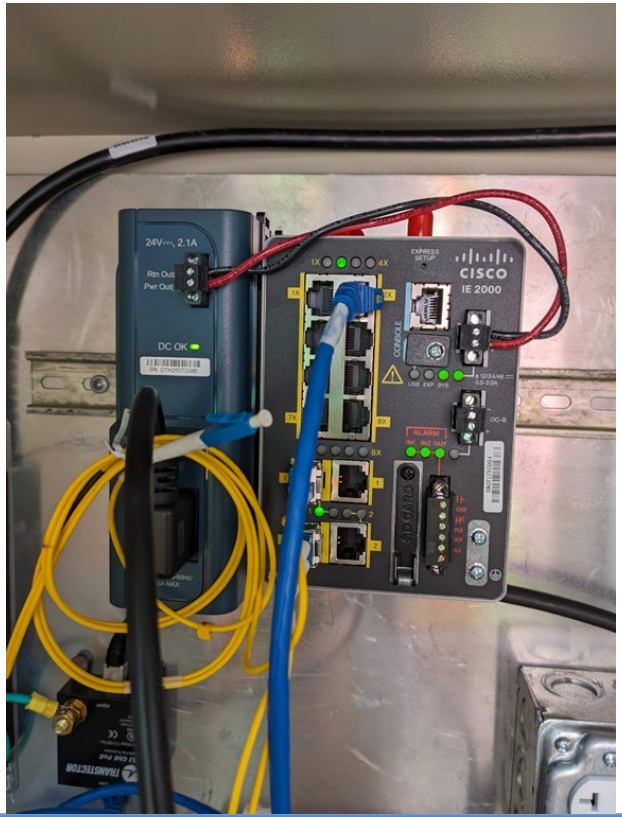
Project Installation Review





Project Installation Cont.





Project Installation Cont.



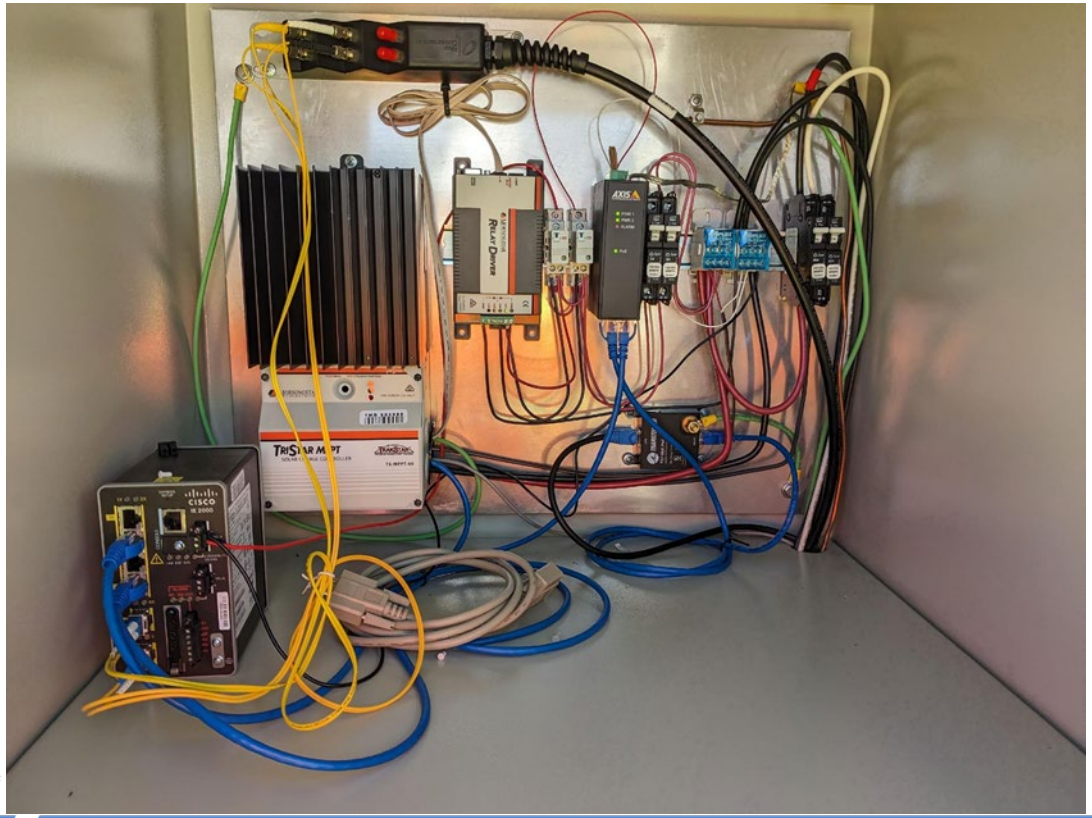


Project Installation Cont.





Project Installation Cont.



Project Installation Cont.



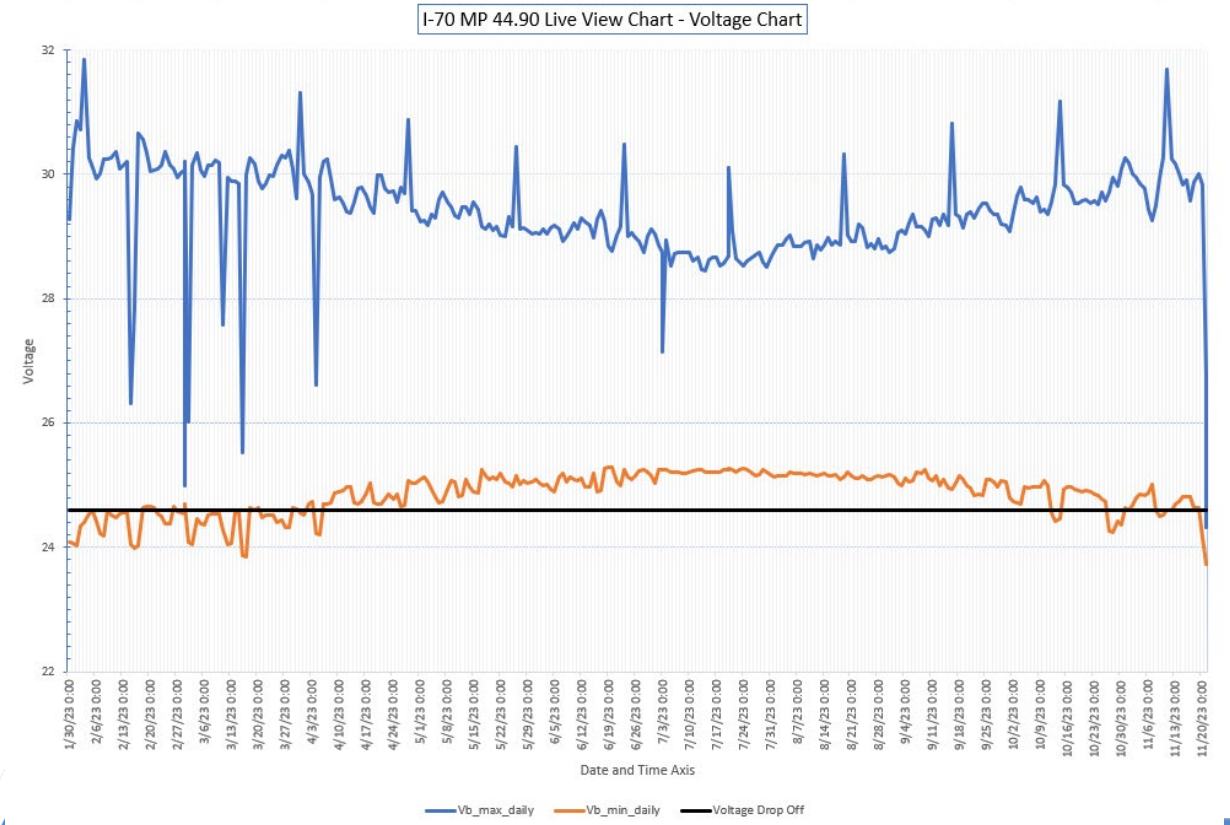


Lessons Learned First Season

Lessons Learned Cont.

- Maintenance crews use cameras in their operations
- Cameras down
  - Maintenance crews call us
- Storms lasting more than three days – Autonomy inadequate
- Cameras go down first, Communication down second
- Understand the equipment and software capabilities
- Had sites within a fiber channel without any resiliency
  - Drop one site, every site downstream goes down

LiveView Site Daily Graph



Back to the Drawing Board

Supercapacitor Modules

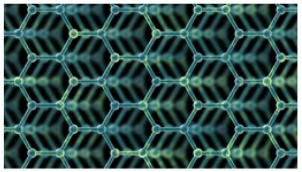






Supercapacitor Technology

Graphene, a sheet of carbon atoms bound together in a honeycomb lattice pattern, is recognized as a "wonder material" due to the myriad of attributes it holds.



It is a potent conductor of electrical and thermal energy, extremely lightweight, chemically inert, and flexible with a large surface area.

It is also considered eco-friendly and sustainable, with possibilities for numerous applications.

Supercapacitor Specifications



- **ZX2000**
  - Voltage Configurations: 24, 36, 48 & 72 VDC
  - Standard size: 17.25” W x 14.25” D x 5.25” H
  - Optional ZX2000-48F**:** 16” W x 10” D x 7” H
- **HZX1000/2000-36**
  - 36 volt 1000/2000 Wh
  - 15” W x 9.2” D x 5.3” H

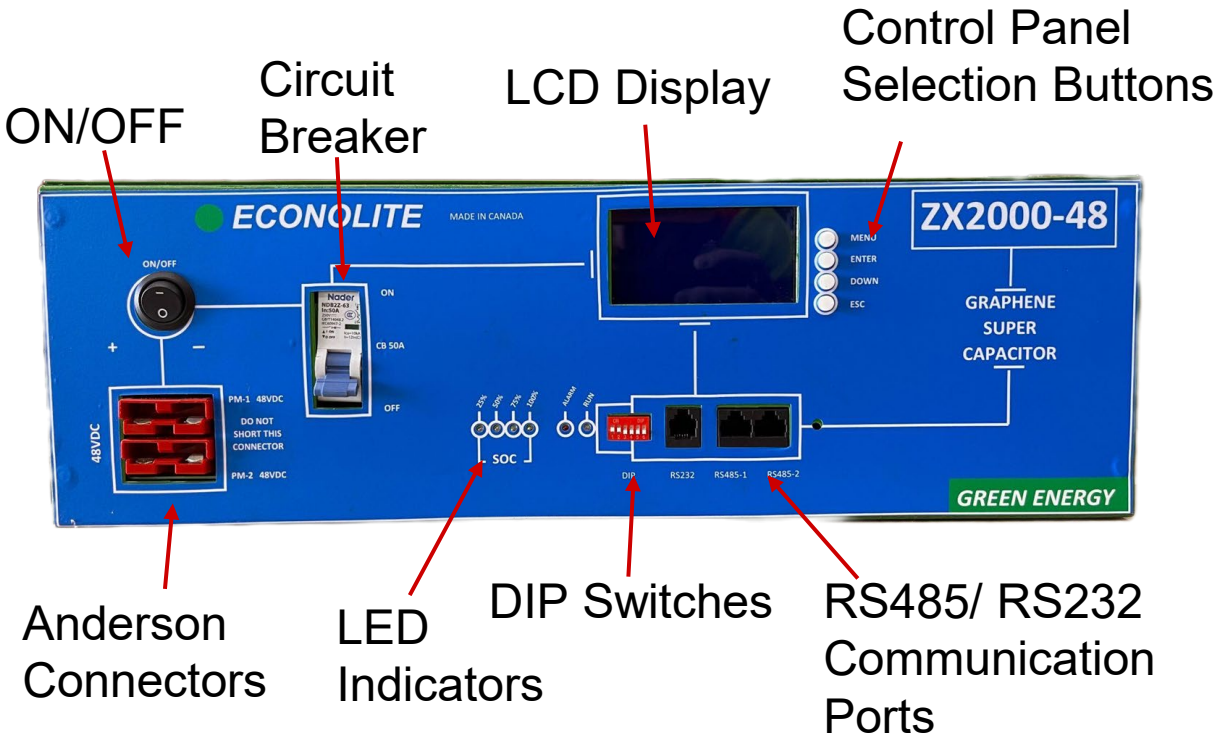
Supercapacitor Variation



ZX2000-48F

- ZX2000-48F
  - 16” W x 10” D x 7” H chassis.
  - Shallower to help fitment.
  - Optional SNMP module.
  - Direct network connection
  - See voltage and status directly

Supercapacitor Features



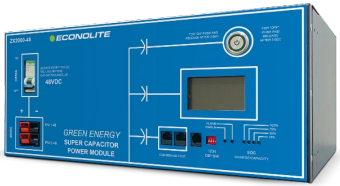
Supercapacitor Features

- Eco-friendly
- 100% recyclable
- 100,000's of discharge cycles
- Long shelf life without cell damage
- Zero Maintenance – Zero environmental impact
- 10-year replacement warranty
- Up to 30 years of service life
- Minimal degradation over life
- Maximum Charge Current: Between 60 A and 100 A
- Single connection to solar charger

Supercapacitor Features

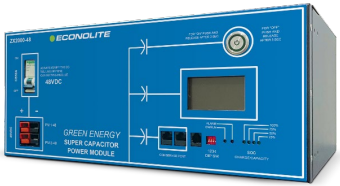
- Short Circuit Protection (Breaker)
- Undervoltage and Overvoltage protection
- Operating range -40°F to +157°F without derating or energy loss
- Does not need space between modules, allowing ‘ZERO’ clearance installations
- Low internal resistance, allowing them to work at close to 100% efficiency
- Significantly lighter than equivalent lead-acid batteries
- Installation may be either in a horizontal or vertical orientation

Increasing Wh Capacity



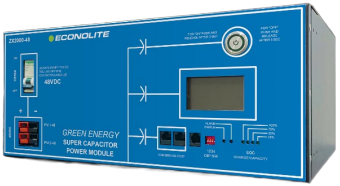
2,000 Wh

+



2,000 Wh

+



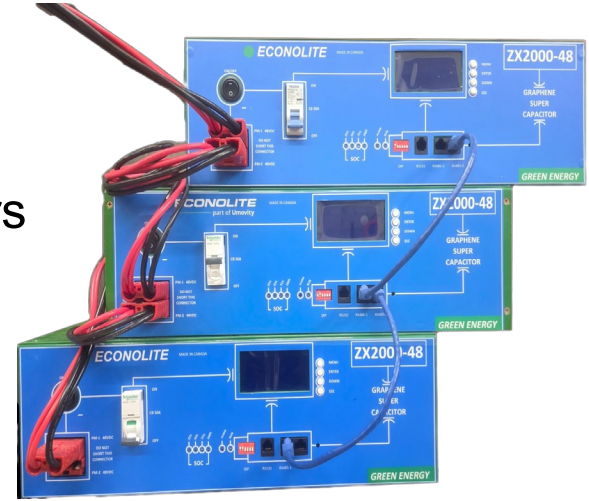
2,000 Wh

Total of 6,000 Wh

Increasing Wh Capacity

Connect up to 10 Supercapacitors

- Extend run time with more Supercapacitors
- Connect multiple Supercapacitors in parallel with manufacturer cables
- Use ethernet cable to connect modules. (Not the network yet)
- Set DIP switches to manufacturer's instructions



Comparisons

Supercapacitors

vs

Lead-Acid Batteries

Comparisons

Supercapacitor
Econolite ZX2000-48

Rating: 2,000 Wh @ 48 V
Dimensions: 17.25” W X 5.25” H X 14.25”D
Weight: 48 lb
Cost: $4,527 each



Lead Acid Battery
NorthStar NSB 190FT Blue+

Rating: 2,196 Wh @12 V
Dimensions: 4.9” W x 12.6” H x 22” D
Weight: 132 lb
Cost: $464 each

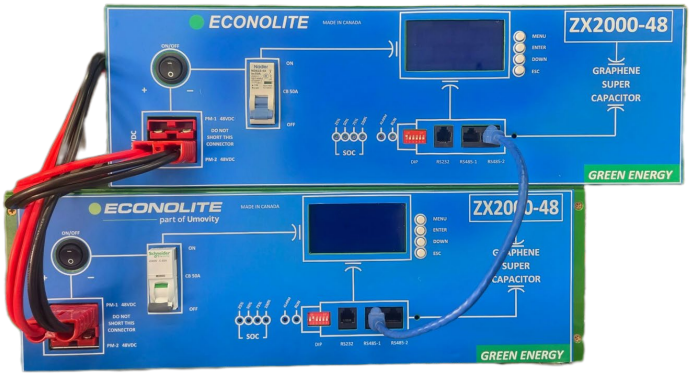


Comparisons

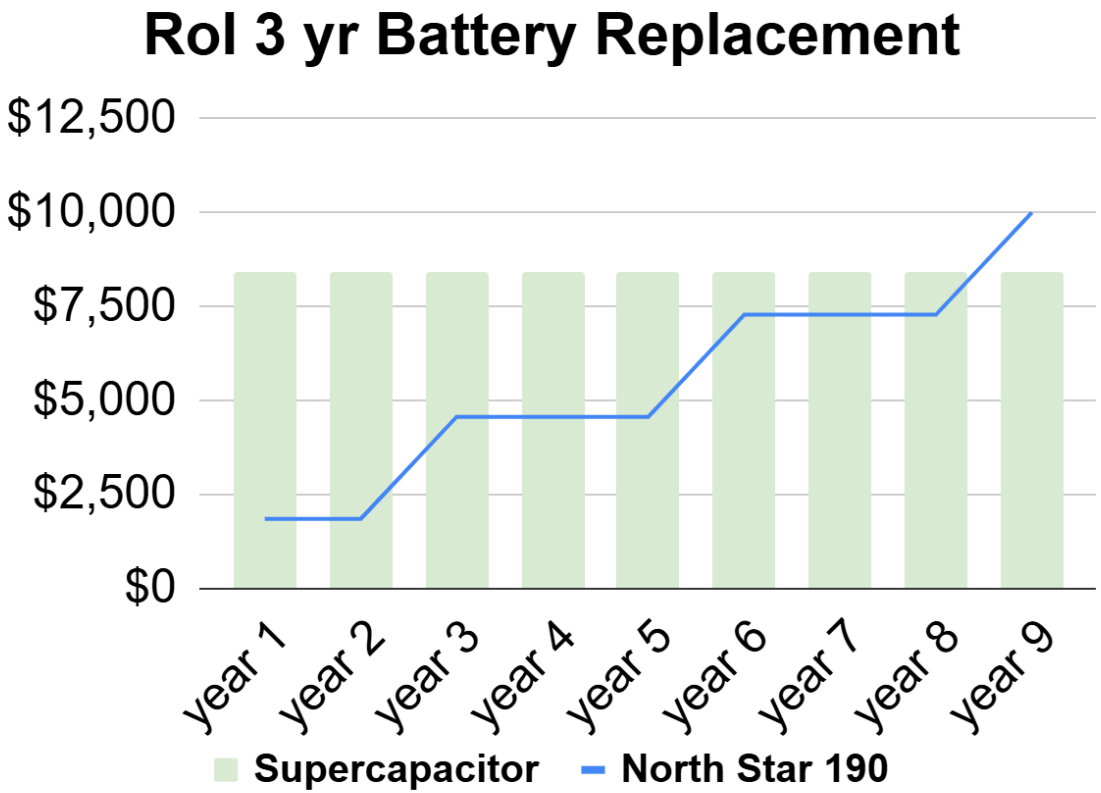
2 - ZX2000-48	NorthStar NSB 190FT (to create 48V)
Rating: 4,000 Wh @ 48 V	8,784 Wh @ 48 V **7,027 Wh temperature* ***5,621 Wh adjusted for 80% DoD*
Dimension: 17.25” X 10.5” X 14.25”	19.6” W x 12.6” H x 22” D
Weight: 96 lb	528 lbs. (4-batteries)

More Information

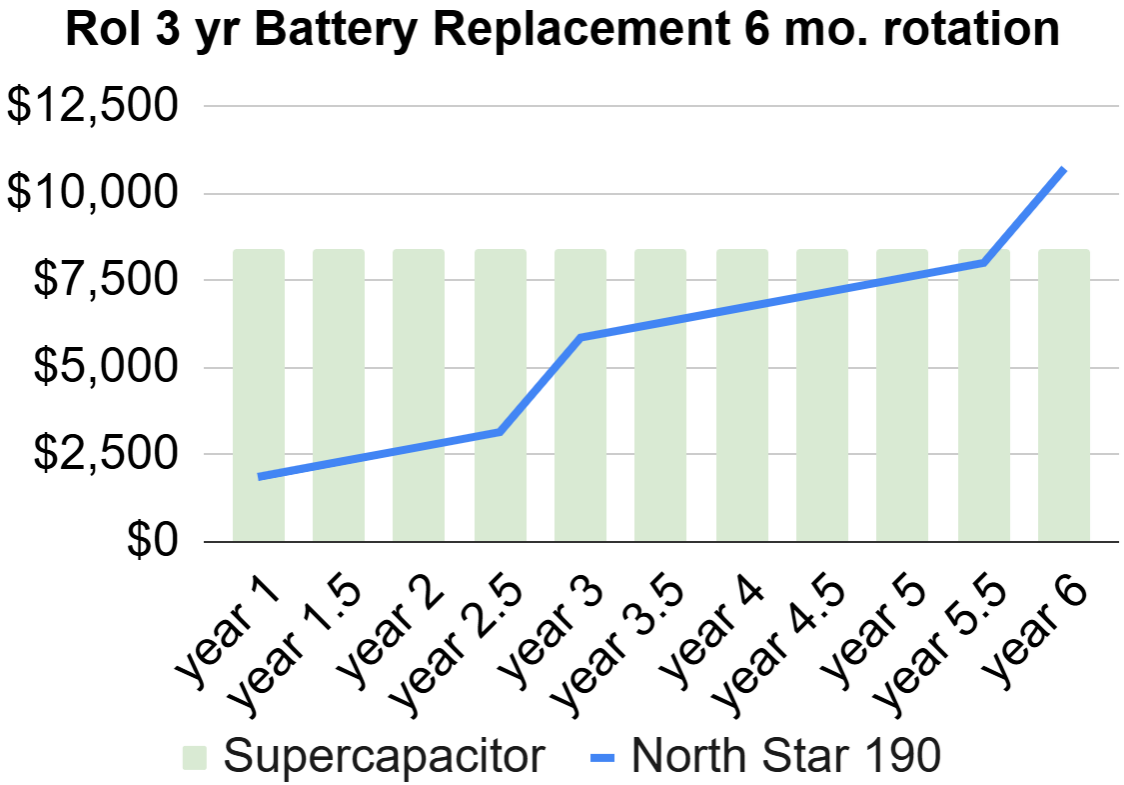
- Cost:
  - $9,054 (2 Supercapacitors)
- Calculated autonomy
  - 4.5 Days



Battery vs. Supercapacitor



Battery vs. Supercapacitor



1st Supercapacitor Installation



From this

To this



- Calculated autonomy
  - 1.8 Days @77 F
  - 1.5 Days @15 F
- Charge time? Varied with temperature

- Calculated autonomy
  - 2.3 Days
  - Unaffected by cold temperature.

2nd Installation - Season 2



Increased battery capacity was necessary



Increased Supercapacitor capacity was available

2nd Installation - Season 2



- Calc. autonomy
  - 8 Days @77 F
  - 7.5 Days @15 F



- Calc. autonomy
  - 4.5 Days
  - Unaffected by cold temperature.

2nd Installation - Season 2



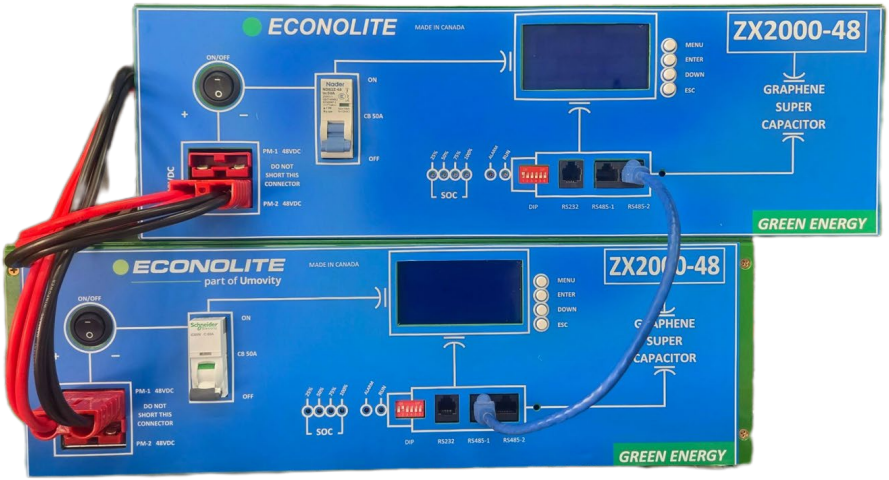


- Run time with solar panel off
  - 6 Days
- Runtime with solar panels off
  - 2.5 Days

Utah's mild winter this year prevented a true test.

Lessons Learned Supercap

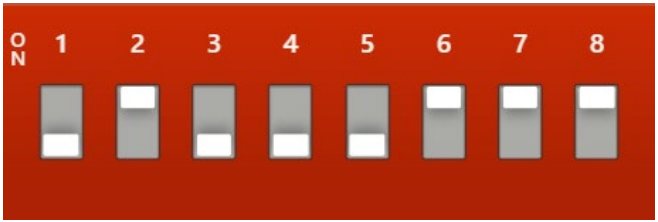
Properly Connect Power and Communication Cables



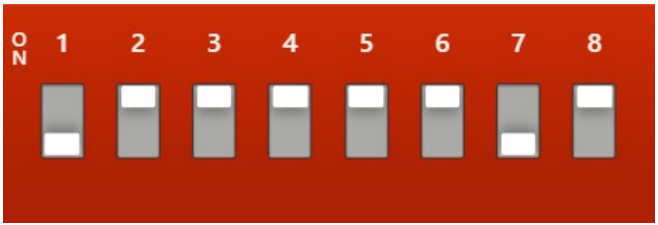
Lessons Learned Supercap

- **Properly set dip switches**

NorthStar NSB
190FT Blue Battery



Supercapacitor



Lessons Learned Supercap

- **State of charge on display and indication lights are unreliable.**
  - To check the status of the Supercapacitor, check the “pack status” voltage
  - All packs should be very close in voltage
  - A failed cell will impact the module exponentially

Lessons Learned Super cap

- **Solar controller programing**
  - Supercapacitors charge differently that lead acid batteries.
  - Absorption and Equalization are not needed.
  - 3-stage battery charging algorithm
    - Night
    - Bulk Charge
    - Float

Will Wind Work?

Not yet



Turbine Design Details

Ryse Energy

- Model: AIR 30 Land 48V
  - 1-AR30-10-48
- Weight: 13 lb
- Rotor Diameter: 46 in
- Startup Wind: 8 mph
- Max. Wind Speed: 90 mph
- Power Production stops: 33 mph
- Rated Power:
  - 400 W @ 28 mph

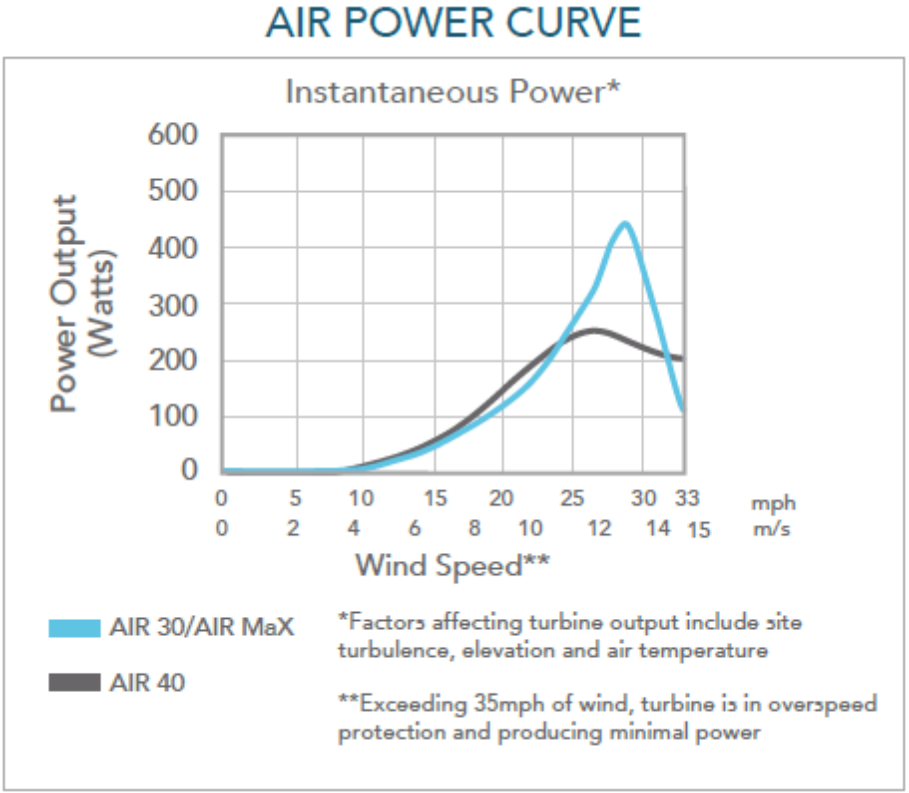


Trubine Design Details

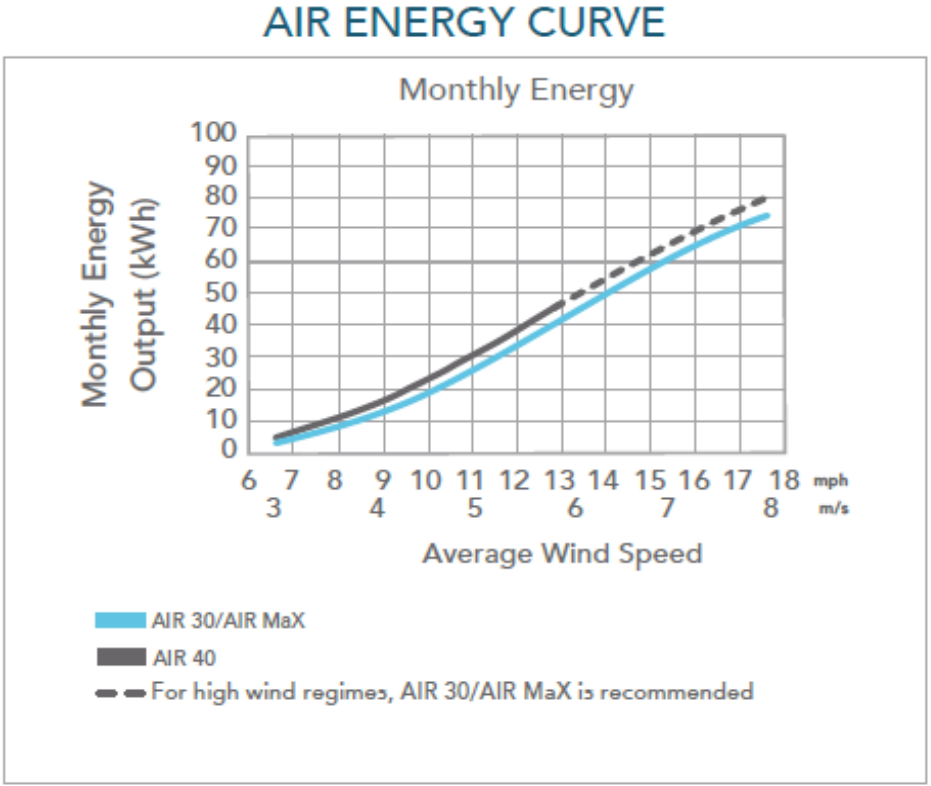
- Max. Wind Speed: 90 mph
  - Power production stops at 33 mph
- Rated Power:
  - 400 W @ 28 mph



Turbine Power Curve



Turbine Power Curve



Equipment Line Diagrams

Solar Camera



Supercapacitors



Solar Charge Controller



Solar panels



Wind generator





Bus / Termination Point

Lessons Learned Over Time

Lessons Learned

Toolbox options:

- Commercial Power – Preferred
- Solar
- Wind
- Various Battery types
- Propane
- Other power storage types

Lessons Learned

Fire mitigation

- Will fire threaten the site?
- Can the site be protected from fires?



Lessons Learned

Location

- Offset from road – the farther the better
- Avoid median installations
- Stock replacement panels
- Work with maintenance on plowing speeds



System Location

Install sites on the southbound side of a divided roadway, when possible.



Lessons Learned

- Do the research.

A little learning is a dangerous thing; Drink deep, or taste not.

Alexander Pope

Tilt-Tower Convenience







Lessons Learned – Site Design

- Need to do the research
  - Use competent and experienced designer
    - The site needs to be designed as a system
  - Select the most efficient components
  - Design each site – Not a cookbook design
  - Load Analysis
  - Critical Design Analysis
    - Load
    - Solar Insolation

Site Design Cont.

- Critical Design Analysis cont.
  - Battery Bank Sizing
  - Array Sizing, Array Orientation
- Battery Bank Configuration
- Consider Existing/Future Loads
- Load Profile (Monthly vs. Annually)
- Energy Consumption
  - Duty Cycle: % Time Load is Operating

Site Design Cont.

- Plan for the Worst
  - High Energy Consumption (Load) – Low Solar Energy (Insolation)
- Critical Design Ration
  - Daily Load: Average Daily Insolation
- Critical Design Month
  - Highest Critical Design Ratio
  - Use this data to size the entire system
  - Increase System Availability – for future equipment

Site Design Cont.

- Battery Capacity is directly dependent on Load Requirements and desired Autonomy
- Determine desired Autonomy
- IEEE Std 1562 solar battery autonomy recommendations
  - 5 to 7 days for non-critical loads located in areas with high solar insolation
  - 7 to 14 days for critical loads or low insolation
- Higher Voltage Systems = Less Current = Greater Efficiency

Lessons Learned

- Equipment added after original design
- Additional equipment added incorrectly
- Battery life shorter than expected
- On a four battery system inner two batteries died before the outer two batteries
- Site on shown to the right was designed for 5.82 days of autonomy but ran for more than 30 days after the fire destroyed the charging system – Don't over design



Lessons Learned - Cameras

Camera Power Settings

AXIS Q6135-LE PTZ Network Camera

Power status

Usage

Current power: **35.98 W**
Average power: **30.64 W**
Max power: **52.97 W**

PoE

PoE class (PSE): **5**
Power requested: **51.00 W**

Power profiles

- (●) **Full power (default)**
  Suitable for temperatures between -50 and 50 °C (-58 and 122 °F)
- ( ) **Low power**
  Suitable for temperatures between 0 and 50 °C (32 and 122 °F)
  Note: The heater will be disabled in this profile

Camera Power Settings Cont.

AXIS Q6135-LE PTZ Network Camera

Power status

Usage

Current power: **9.56 W**
Average power: **30.64 W**
Max power: **52.97 W**

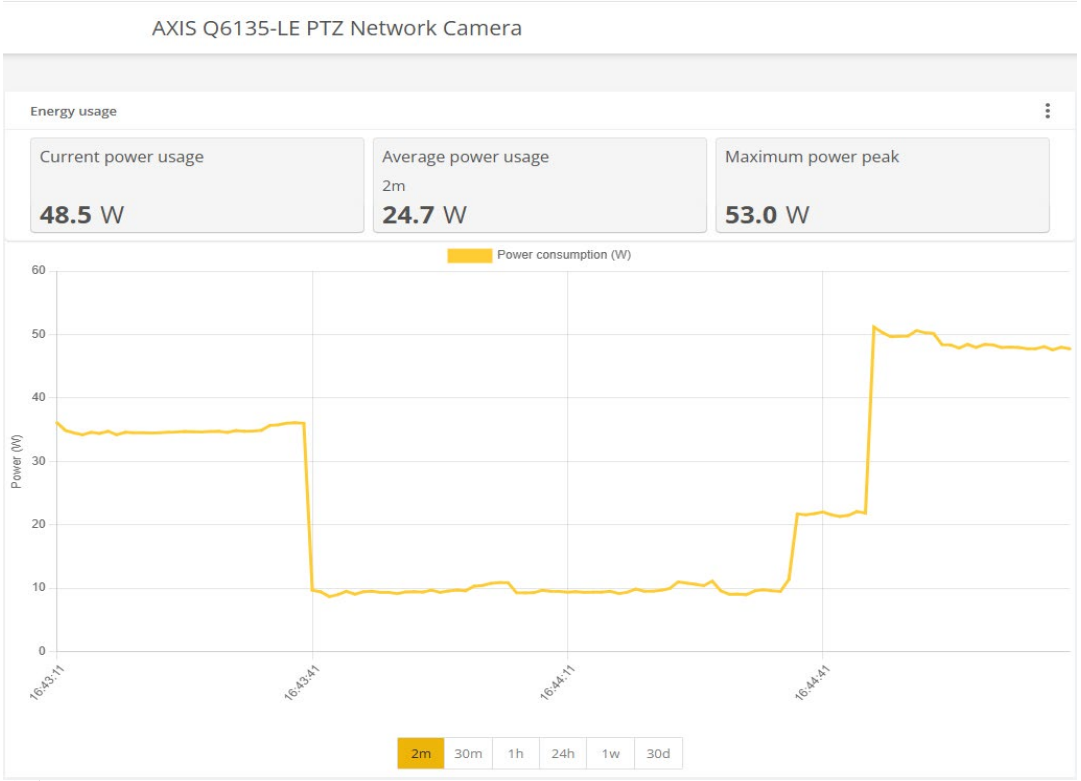
PoE

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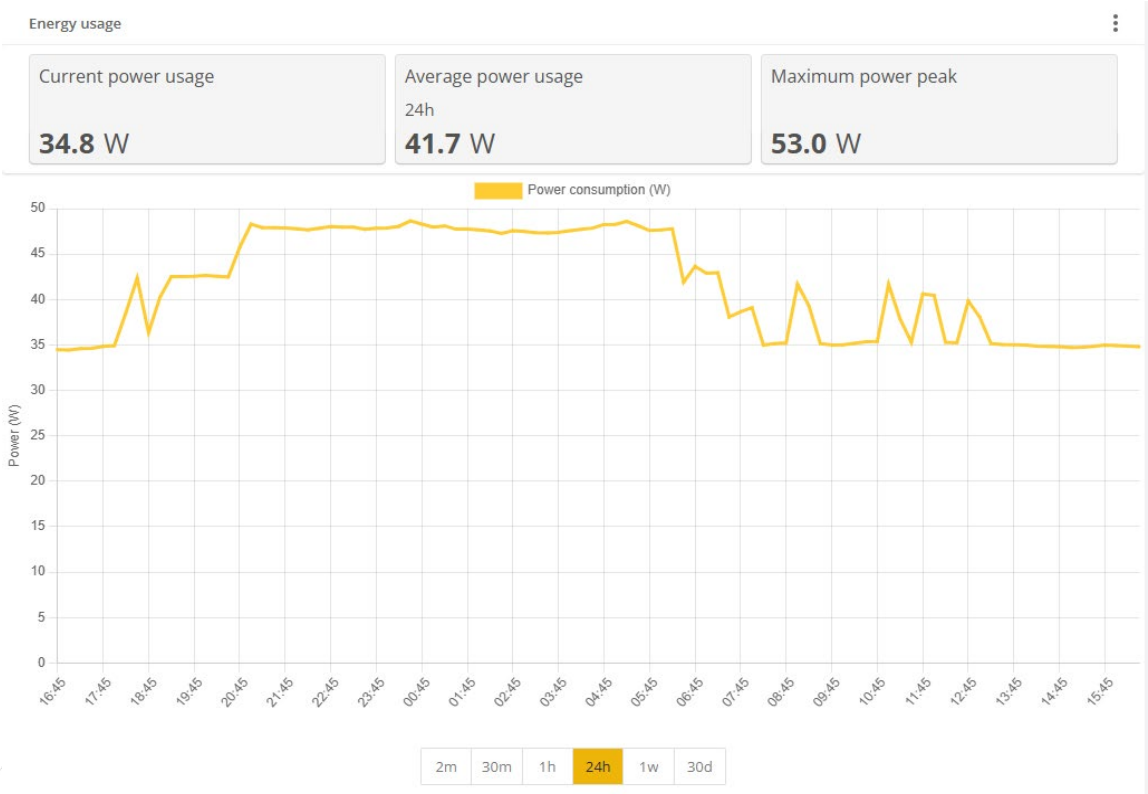
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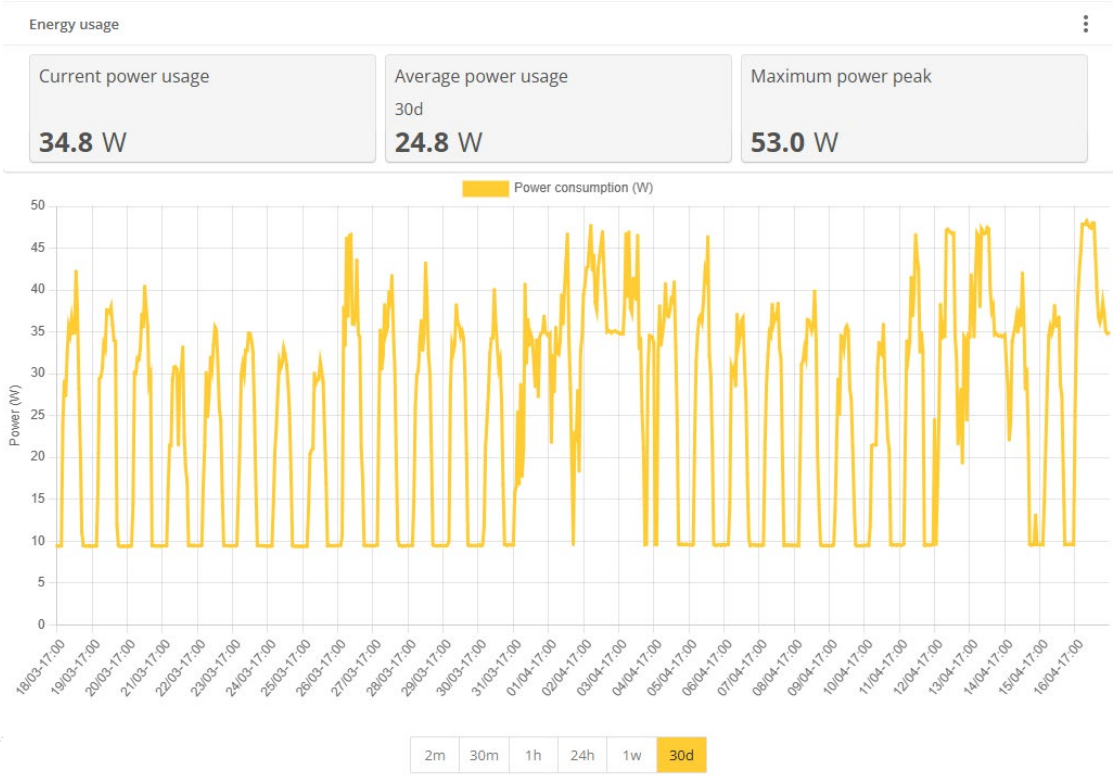
Camera Power Settings Cont.



Camera Power Settings Cont.



Camera Power Settings Cont.



QUESTIONS?

udot.utah.gov

Conclusion

Special Thanks to our Team for their assistance.

- Garret Chaston – UDOT Engineering Intern
- Quaid Mackert – UDOT Engineering Intern
- Bryce Bair – Electronic Signal Technician II
- Josh Massa – Electronic Signal Technician II

We couldn't have made this happen without them!

Tyson Larson
UDOT Region Four
Electronics Supervisor

Phone: 801-830-9556
email: tlarson@utah.gov

THANK YOU

Troy C. Torgersen
UDOT Region Four
ITS Manager/ Signals Engineer

Phone: 435-896-0711
email: ttorgersen@utah.gov

udot.utah.gov