One Megawatt Solar Array for Grand Canyon West

LAND AREA FOR ARRAY: 3.7 ACRES

PROJECT BUDGET: $3,690,000

DEPARTMENT OF ENERGY GRANT: $2,430,000 (DE-IE0000128)

TRIBAL MATCH: $1,260,000 FROM VARIOUS SOURCES INCLUDING FREEPORT MCMORAN

Prepared for: Department of Energy, Office of Indian Energy
Prepared by: Hualapai Tribal Utility Authority and Planning Dept.
November 18, 2024, DOE Program Review

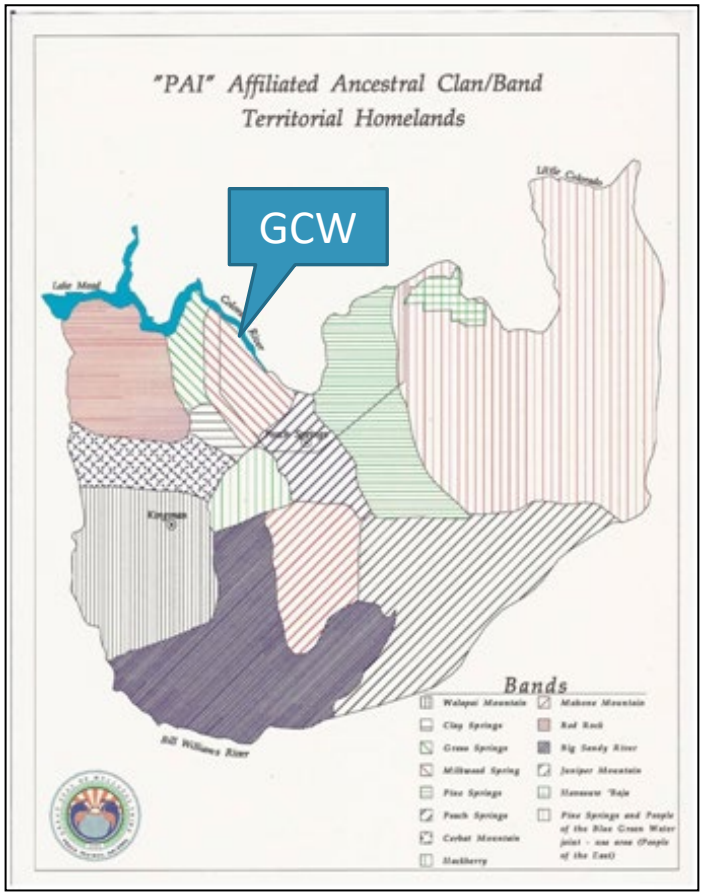
Introduction to Hualapai

The People of the Tall Pines, 2,394 enrolled members as of February 20, 2024 with 1,245 living on the Reservation.

Reservation comprises approximately one million acres established by Executive Order in 1883.

Traditionally, Hualapai inhabited an area up to seven million acres, with archeological evidence dating to 600 AD.

The homeland stretched from the Grand Canyon southward to the Bill Williams and Santa Maria Rivers and from the Black Mountains eastward to the San Francisco Peaks located near what is today Flagstaff, Arizona.



Hualapai Population

Population

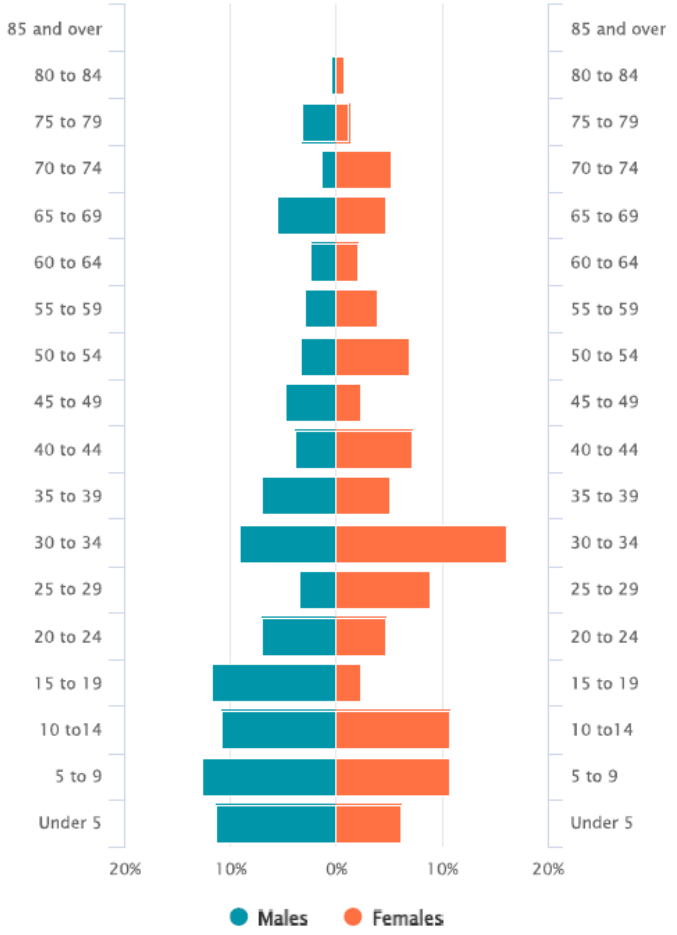
- Median age is 30.1 years
- 513 households
- Average household size is 3.15 persons
- 27% of adults do not have a high school diploma

Employment & Poverty

- Sectors include arts & entertainment, education, transportation, and government
- Labor participation is 43% for those 16 years of age and older.
- Unemployment rate = 20.4% (pre-Pandemic)
- Median Annual Income = $37,679
- Poverty rate = 35.3%

Housing

- 578 dwelling units (513 occupied)
- $60,300 median home value (91% SFDUs)
- 73% of homes have internet subscription



Source: 2020 Census and
2016-2020 American Community Survey

Grand Canyon Resort Corporation Profile

Founded in 1988 with operations in Peach Springs and Grand Canyon West to administer several enterprises employing 350 full and part-time employees as follows:

Grand Canyon West - Skywalk & Western Town

Hualapai River Runners & Pontoons

Hualapai Lodge & Diamond Creek Restaurant

Walapai Market and Fuel Station

Approximately 5,000 tourists take the rafting trip each year with most staying at the Hualapai Lodge in Peach Springs the night before.

Visitation to Grand Canyon West averaged some 1,000,000 persons per year from 2015 thru 2019. Visitation for the first 9 months of 2022 is 555,000 as the tourist industry recovers from the Pandemic.

Project Summary

In 2014, the tribal council formed the Hualapai Tribal Utility Authority to connect GCW to the regional electric grid via a new 69 KV line from an off-reservation utility. The tribe's diesel generators provide the only form of electric service to this part of the reservation.

The micro-grid, also commissioned in 2014, is composed of three Caterpillar 750 KW diesel generators, energizing some five miles of buried 20.8 KV, 3-phase cable, and has an extremely high operating cost and is prone to go offline for scheduled repairs which become more frequent after 20,000 hours of generator run time. After the numerous delays and setbacks to connect the tribe's new power line to the grid, the HTUA began exploring a solar option in 2019 to save costs and extend the life of the generators.

The goal of the project is to improve the resilience of the non-grid-connected electrical generation system at GCW to withstand short-term disruptions and rising energy costs by installing a 885-kW solar PV and 750-kW/2,145-kWhr battery storage system.

The system will be capable of providing some 1,600 MWhrs per year (25 year lifetime average) or about 50% of the annual energy needed at GCW to supplement the existing diesel generator energized micro-grid, saving approximately $450,000 in fuel cost per year and over $11 million dollars over the 25-year life of the system. These dollar values will likely increase as the price of diesel fuel rises over the next decade.

Project Time Line & Issues

Amended Statement of Project Objectives submitted to DOE (Federal Fiscal Year)														
Milestone	3Q 2021	4Q 2021	1Q 2022	2Q 2022	3Q 2022	4Q 2022	1Q 2023	2Q 2023	3Q 2023	4Q 2023	1Q 2024	2Q 2024	3Q 2024	4Q 2024
Pre-Construction														
Site Characterization														
Preliminary Design														
Engineering														
Procurement														
Construction														
Commissioning														
Monitoring														
Closeout														

Issues Encountered:

1. Connection to GCW Micro-Grid Cat 750 Generators
   a) Upgrade of Caterpillar controllers from EMCP 4.2 to 4.4 ($110,000)
   b) Setting Cat 750s to run in “droop” mode (grid following) from Asynchronous mode, a role which is now handled by the Tesla Site Controller.
   c) Unexplained generator shut down on February 18, 2024.
2. Requesting Tesla swap out AT&T modem for a Verizon unit since they are the only cell service.
3. Technology decisions were recommended by design-build contractor – Solon
4. Some early-afternoon curtailment of the PV array when battery is fully charged and loads are light.
5. Operations have been smooth except for 2/18/2024 “Black Start” event and Zig-Zag transformer failure on 7/18/2024.

Project Background - Conception through Initial Site Selection

Spring of 2019: HTUA requests staff to look into developing a solar project at Grand Canyon West to help power the micro-grid, save on diesel fuel costs and reduce emissions.

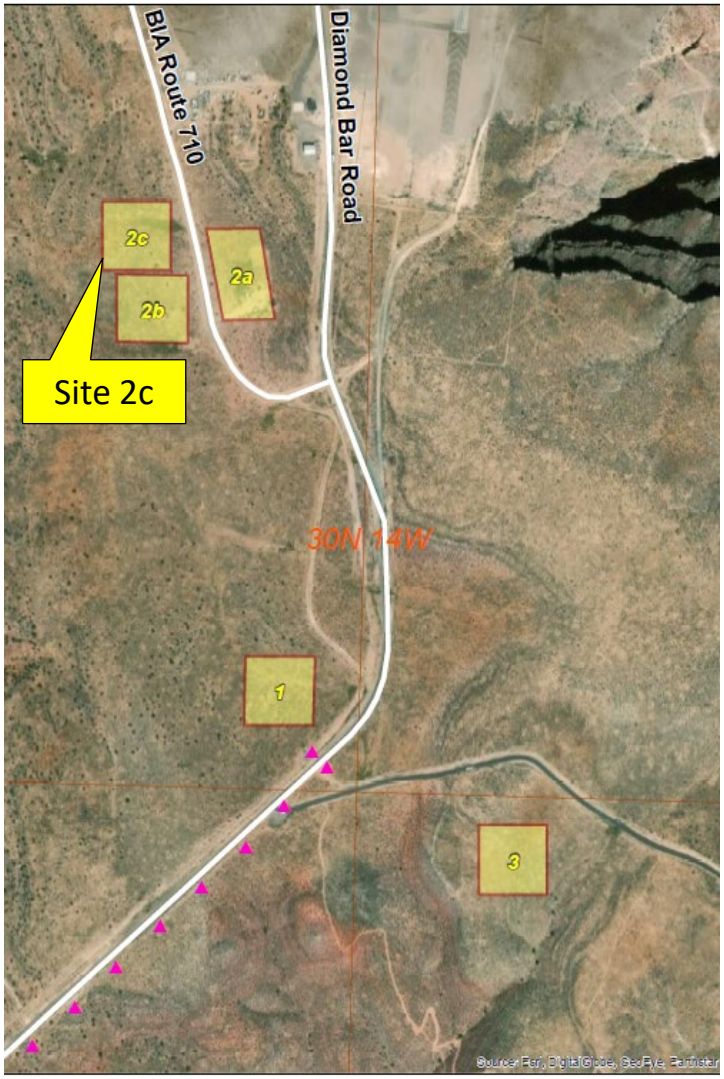
Summer of 2019: HTUA requested proposals from vendors to construct a 2 MW solar array at Grand Canyon West to cover 100% of micro-grid's output.

October 2019: Discussion with tribal council on the cost of the project led to a reduction in scope to a 1 MW solar array to offset 50% of micro-grid's energy needs. HTUA issues addendum Nos. 5 & 6 with Solon's proposal considered the most responsive & responsible.

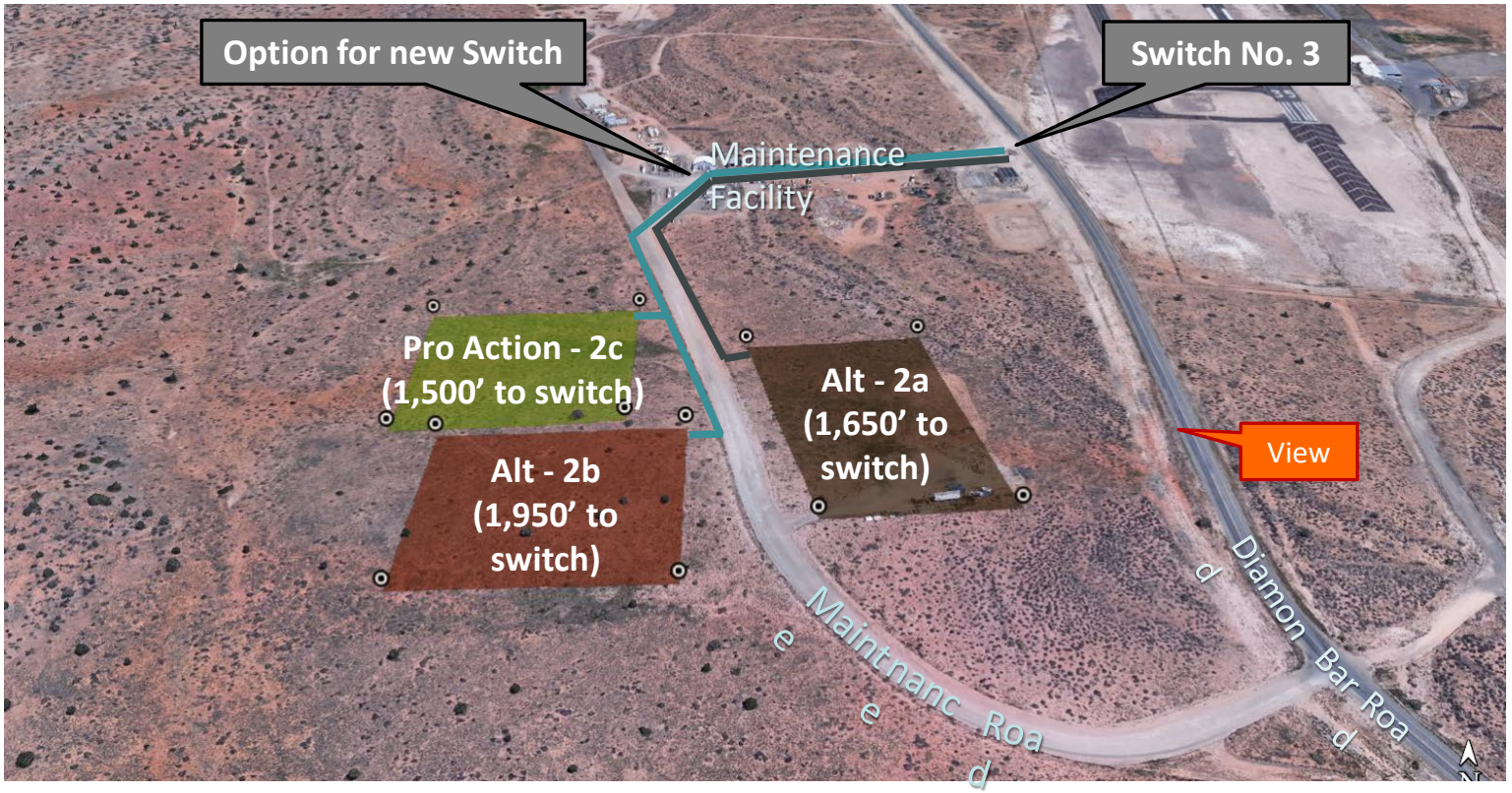
February 2020: Hualapai updates 2012 BIA feasibility study applies to DOE for a grant to fund a 1 MW solar array with a lithium battery bank.

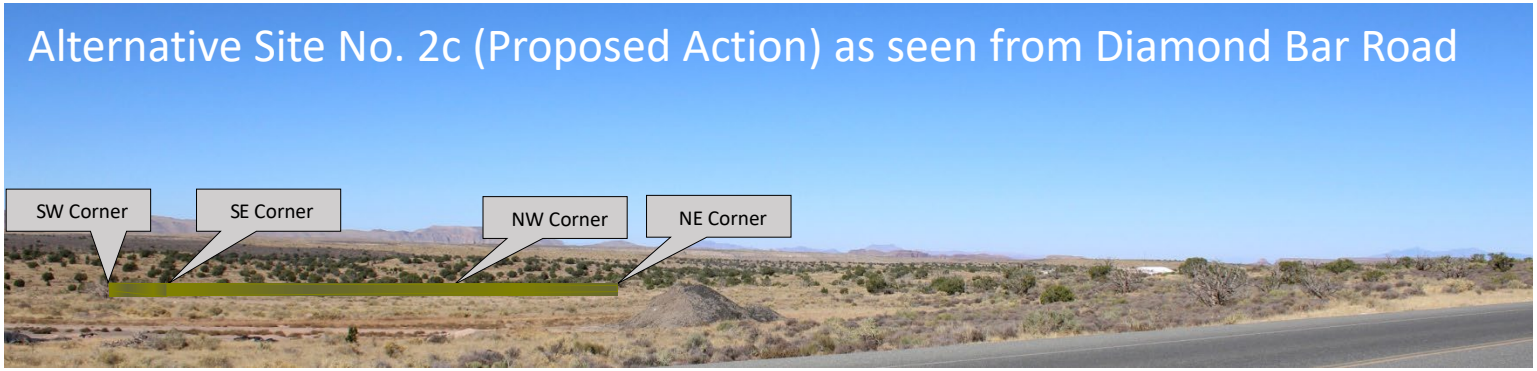
May 2020: DOE notifies tribe of successful application and begins negotiations on $2.7 million award w/ tribe contributing $1.35 million (50/50 match).

Summer of 2020: Planning begins work on EA with input from IDT, TERC, HTUA, GCRC, FAA and DOE. Public survey and radio interview done in November 2020 to discuss preferred location of solar array.



Solar Array Alternate Site Nos. 2a, 2b & 2c (Proposed Action)





Project Background Thru Environmental Assessment Approval

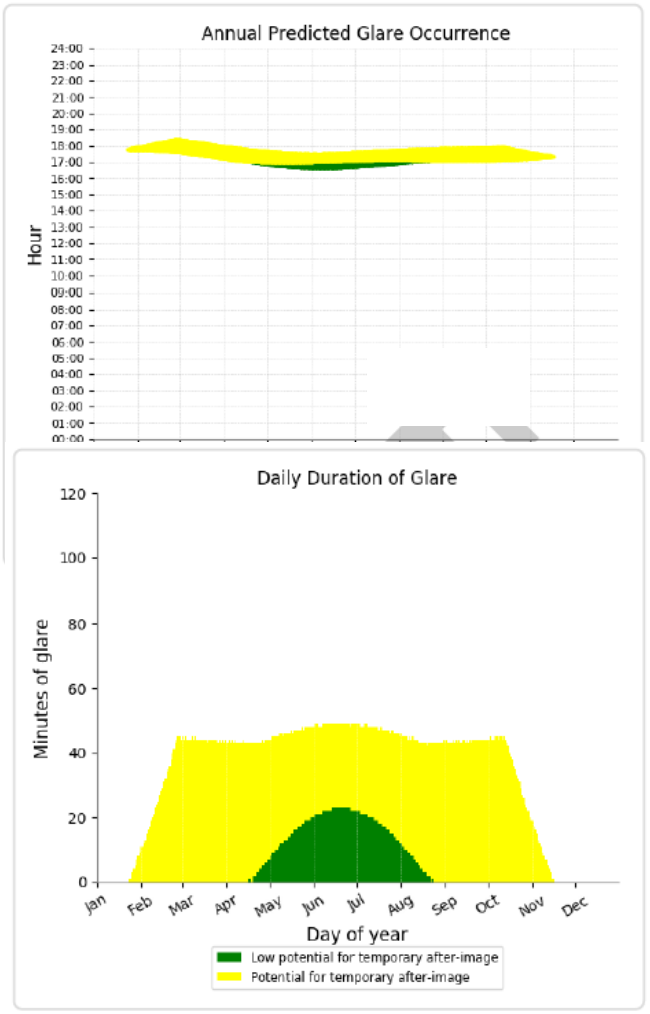
November 2020: Tribe requests reduction in cost share and receives approval from DOE for 10% match ($270,000) on December 29th.

December 2020: TERC reviews community surveys and preliminary glare analysis and recommends Site No. 2c as the Proposed Action in the draft EA. Site location adds $400,000 to project cost to extend 20.8 KV electrical line to nearest micro-grid switch.

February 2021: Draft EA distributed to IDT, TERC, HTUA, GCRC and tribal council for review and input.

April 27, 2021: Tribal Council recommends Site No. 2c which allows for future expansion for a 100% solar power solution at GCW.

May 19, 2021: TERC approves EA with FONSI signed in June. General Permit held until council review upon completion of contract negotiations between vendor and HTUA.



Project Status Since Approval of Environmental Assessment

July 2021: HTUA solicits third-party cost estimate which calculates $2,705,983 to construct the fence-line project.

August 2021: DOE's contracting officer approves Solon as the competitively selected vendor and approves the NEPA review performed by the tribe.

September 2021: Solon requests a price increase due to rise in aluminum, steel and copper prices bringing the cost to $2,967,589. Price is still lower than bids received by other vendors in 2019.

October 2021: HTUA's estimate for off-site work to connect array to micro-grid increases from $400,000 to $500,000 (25% increase) based on Solon's cost increases.

Summer to Early Fall 2021: Contract with Solon reviewed and revised by HTUA Board and attorney over a four month period to address questions of tribal sovereignty. Tribal council signs contract on November 6, 2021, to allow engineering to start.

May 9, 2022: Tribal council approves battery upgrade & of screw mounts increasing contract to $3,277,558.

October 11, 2022: Groundbreaking.

June 22, 2023: Mechanical completion.

October 18, 2023: Array goes on-line with final payment to Solon on 11/17/2023.

Construction Photos

Clearing 3.7 Acre Site

Pre-Drilling for Screw Anchors

Screw Anchors for PV Module Rack

Solar Array and Equipment Pads

Off-Loading MegaPack

20.8 KV Grid Extension to Array

Site Photos of Completed Project


Two CPS 60 KW String Inverters


Communications & MegaPack


Mr. Anderson describes Comm Sys


Solar Array within fence line


Solar Array from Newtown Road


Solar Array from Diamond Bar Rd

GENERAL NOTES:

1. INVERTERS AND AC COMBINER PANELS MAY NOT BE DRAWN TO SCALE. THEY ARE SHOWN FOR DIAGRAMMATIC PURPOSES ONLY.
2. SEE THREE LINE DIAGRAM: PV SUBARRAY SHEET(S) FOR DETAILED STRINGING DIAGRAM.
3. THIS DIAGRAM DOES NOT REFLECT THE WIRING METHOD THAT WILL BE USED. THIS DIAGRAM IS FOR DESCRIPTIVE PURPOSES ONLY, PLEASE REFER TO PV SUBARRAY THREE LINES FOR DETAILED WIRING DESCRIPTION.

PV INACTIVE PANEL (NOT USED)

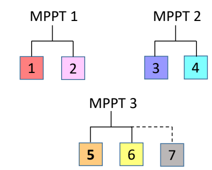
STRINGING PATH

ARRAY OUTLINE

SYSTEM DESCRIPTION

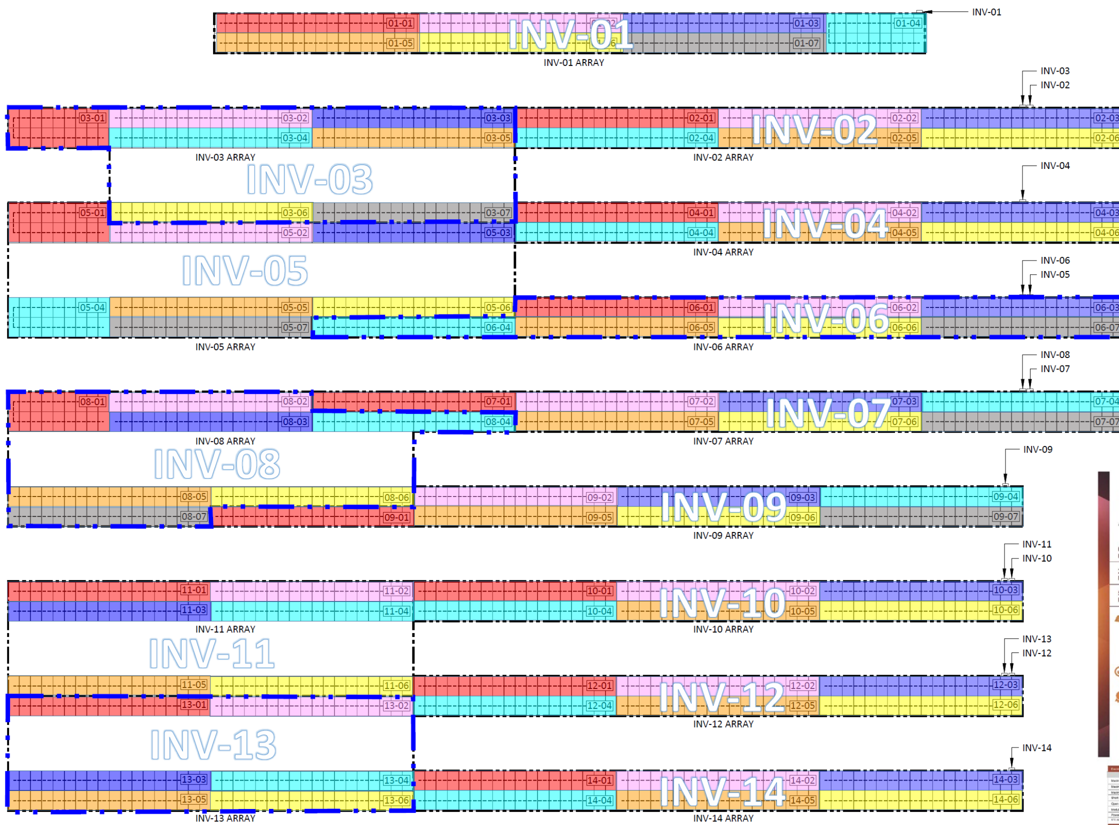
PROJECT SUMMARY											
ARRAY	TILT	AZIMUTH	PANEL BOARD	INVERTER	INVERTER TYPE	ACTIVE MODS	STRINGS	MODS / STRING	kWac	kWdc	DC/AC RATIO
A	26	180	PNL-01	INV-01	A	126	7	18	60	68.04	1.13
				INV-02	B	108	6	18	60	58.32	0.97
				INV-03	A	126	7	18	60	68.04	1.13
				INV-04	B	108	6	18	60	58.32	0.97
				INV-05	A	126	7	18	60	68.04	1.13
				INV-06	A	126	7	18	60	68.04	1.13
				INV-07	A	126	7	18	60	68.04	1.13
				INV-08	A	126	7	18	60	68.04	1.13
			PNL-02	INV-09	A	126	7	18	60	68.04	1.13
				INV-10	B	108	6	18	60	58.32	0.97
				INV-11	B	108	6	18	60	58.32	0.97
				INV-12	B	108	6	18	60	58.32	0.97
				INV-13	B	108	6	18	60	58.32	0.97
				INV-14	B	108	6	18	60	58.32	0.97
Totals						1638	91		840	884.52	1.05

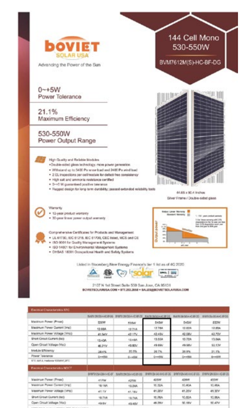
String Association with Inverter MPPTs



Solar Project Summary		
Component	*Count*	*Description*
Modules	1,638	Boviet Bi-Facial 540W (144 Cells)
Inverters	14	CPS 60KW (6 to 7 strings per Inv)
Strings	91	2 to 3 Strings per MPPT
Modules/String	18	36 to 54 modules per MPPT
KWDC	885	
KWAC	840	

1 INVERTER SPECIFICATION SHEETS





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HUALAPAI - GRAND CANYON WEST

884.52 KW-DC, 840 KW-AC PHOTOVOLTAIC, 770kW, 2145kWH BESS PROJECT

5001 DIAMOND BAR RD PEACH SPRINGS, AZ 86434

STRINGING PLAN

REVIEWED FOR CODE COMPLIANCE BY: WILLDAN ENGINEERING
Approval of these plans & specifications shall not be construed to be a permit for, or an approval of any violation of any Federal, State, County or City laws or ordinances. One set of approved plans must be kept on the job until completion.
2:06:23 PM Sep 26, 2022

PROJECT SC21-028

	INITIAL	DATE
ENGINEER	FA	9/6/22
DRAFTER	FA	9/6/22
CHECKER	JM	

SHEET # **E2.1**

VERSION: 01

Payback-Fuel Savings and Maintenance from Feasibility Study

Solar array will supply 48% of the energy requirements for the GCW micro-grid and reduce other operating costs by 20%. (Labor-Service Contract)

CURRENT GCW Generator Operating Costs					Projected Yearly Savings	
		2018	2019	Average		
1. Diesel - Red Dye	Fuel	$1,048,751	$808,243	$928,497	$445,679	48%
2. Grid Generator Service Agreement	Maint.	$106,140	$113,464	$109,802	Note 1	20%
3. Grid generators - Labor Parts	Maint.	$228,000	$203,000	$215,500	Note 1	20%
	Total	$1,382,891	$1,124,707	$1,253,799	$445,679	Annual Savings

Note 1: Reduction in diesel generation Maint. costs offset by solar Maint. cost.

Hualapai Tribe will recover its $1,260,000 investment in approximately 35 months*

** Increasing diesel prices will likely reduce the pay back period to less than 24 months*

Technical Considerations - Primary Infrastructure Additions

1. Anchoring of solar panels & fence into shallow granite bedrock
2. Construction and installation of:
   i. Solar panels and racking system
   ii. Concrete pads/conduits/fence
   iii. Tesla Battery Mega Pack with system site controller
   iv. Step-Up Transformer, ground detection, electrical switchgear
3. 1,200’ extension of existing 20.8 KV micro-grid to solar site
4. New fiber optic communications path between existing generators and battery/solar system to ensure constant communications between the Solar and Diesel site which are nearly a mile apart.
5. Change out existing generator “EPIC” controls from EMCP 4.2 to 4.4
6. Requesting Tesla swap out AT&T modem for a Verizon unit.

Technical Considerations - Operational/Maintenance

1. Tesla Mega Pack and controller provide “grid forming functions.” voltage regulation and frequency control
2. Typical solar installations rely on the regional electrical grid to provide “grid forming functions”
3. Existing diesel generators follow the Mega Pack’s “lead” but revert back to “grid forming” if the battery system is unavailable due to:
    i. Lack of solar irradiation or battery charge falls to less than 20% of rating
    ii. Loss of communications path
    iii. Micro-grid interruption
4. Creation and monitoring of a generation dispatch model and optimization of integrated system
5. HTUA created a Generation Manager position to ensure proper operation and maintenance

Technical Considerations Summary

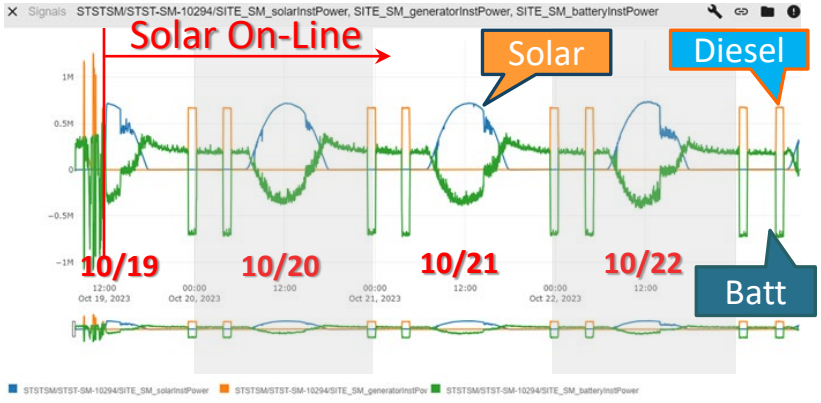
The resulting system is at the forefront of today's deployed Solar technology in Indian Country and non-Indian Country as well

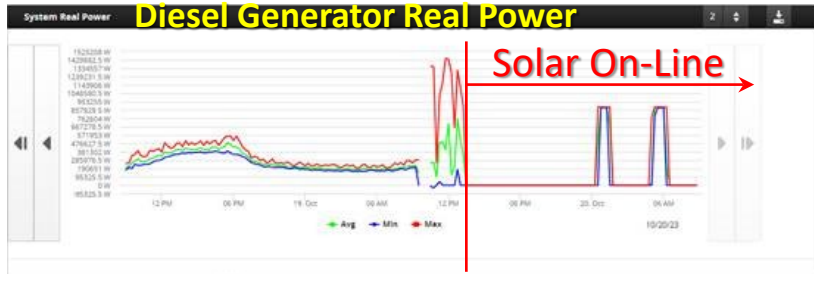
- All electric assets are owned and operated by the Hualapai Tribe thru its utility - HTUA
- The Hualapai Tribe distributes power throughout the GCW campus via its own 20.8 KV underground micro-grid
- The 9,000 acre GCW campus is not connected to the regional utility grid operated by UniSource which serves this part of AZ
- The tribe's prior experience with solar installations is from 3 KW residential, grid-tied to 17 KW ground-mounted systems
- The Hualapai Tribe independently managed all permitting, engineering, procurement & construction for the project, with Solon being the third-party solar contractor

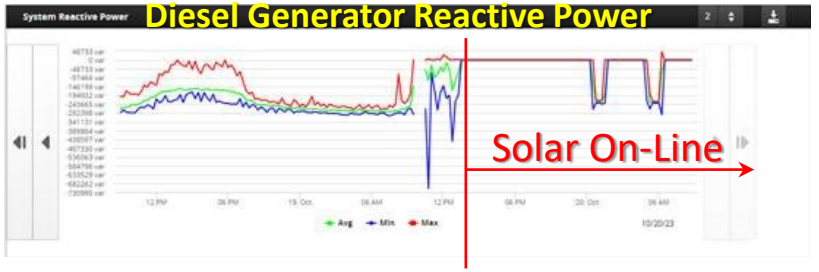
Generation Sources from 10/19 thru 11/4/2023

Solar produced 60% of GCW's energy requirements during the first few weeks of operation

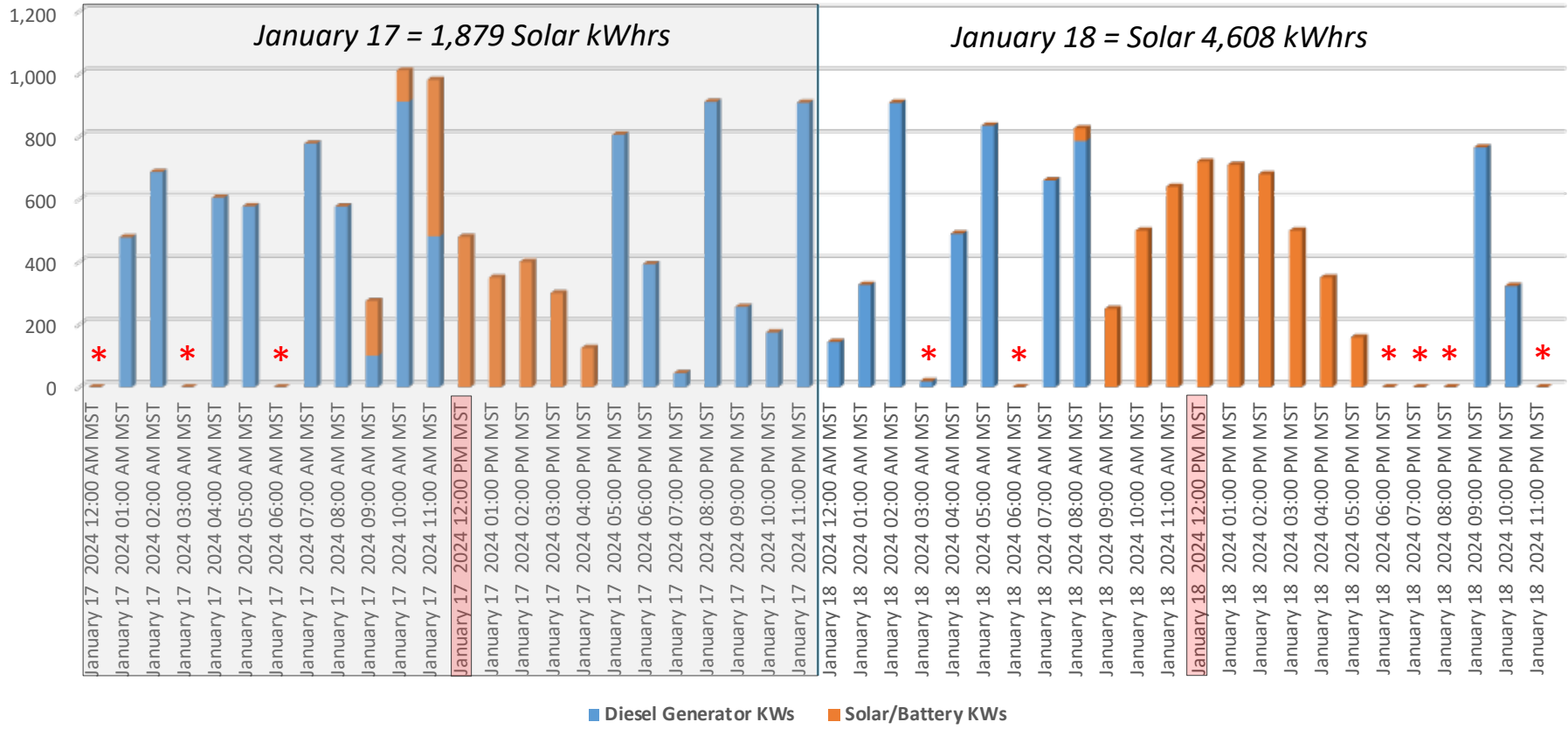
Date	Solar	%	Diesel	%	Total
10/19/2023	5,109	59%	3,547	41%	8,656
10/20/2023	5,051	72%	1,917	28%	6,968
10/21/2023	4,827	59%	3,294	41%	8,121
10/22/2023	4,328	75%	1,427	25%	5,755
10/23/2023	4,126	68%	1,898	32%	6,024
10/24/2023	4,141	68%	1,940	32%	6,081
10/25/2023	4,017	61%	2,536	39%	6,553
10/26/2023	3,943	64%	2,262	36%	6,205
10/27/2023	4,339	82%	967	18%	5,306
10/28/2023	4,536	61%	2,879	39%	7,415
10/29/2023	4,878	97%	174	3%	5,052
10/30/2023	3,847	54%	3,285	46%	7,132
10/31/2023	3,748	54%	3,187	46%	6,935
11/1/2023	4,699	70%	2,037	30%	6,736
11/2/2023	4,433	69%	2,017	31%	6,450
11/3/2023	4,320	68%	2,011	32%	6,331
11/4/2023	4,023	60%	2,697	40%	6,720
Total	74,365	66%	38,076	34%	112,441







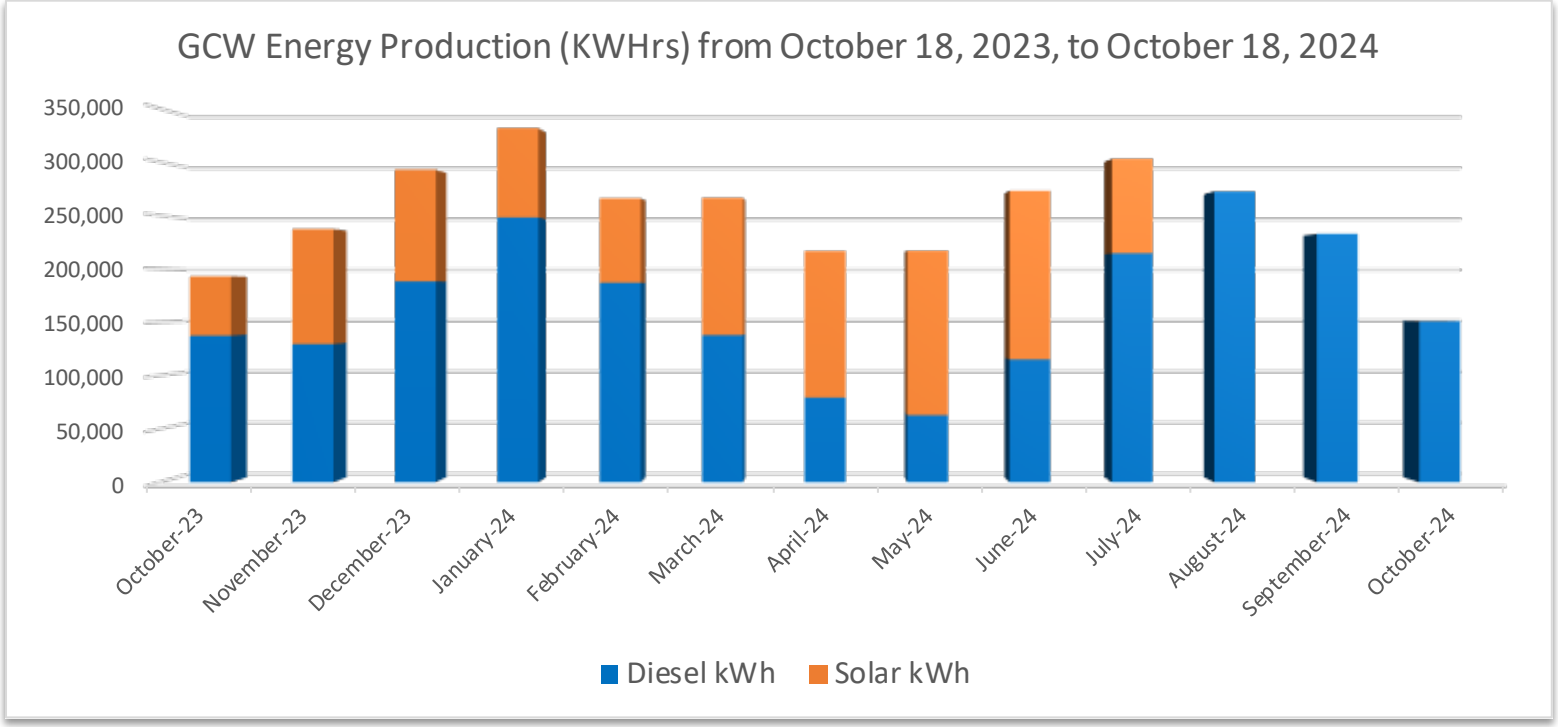
Comparison of Generation



* MegaPack powering micro-grid. Generators will start when battery falls below 50% state of charge

Solar Noon at 11:45 AM, PST

Power Production



- Estimated reduction in generator diesel fuel use by some 210,000 gallons equaling a cost savings of over $600,000 in nine months.
- The system is running near 90% efficient with about half of the power loss attributable to the DC solar to AC conversion, which matches Solon's designed de-rating from 885 KVDC to 840 KVAC, then another 4-5% loss from the Mega Pack tp the Zig-Zag transformer and then through the 20.8 KV step-up transformer as the power exits the fence line onto the micro-grid.

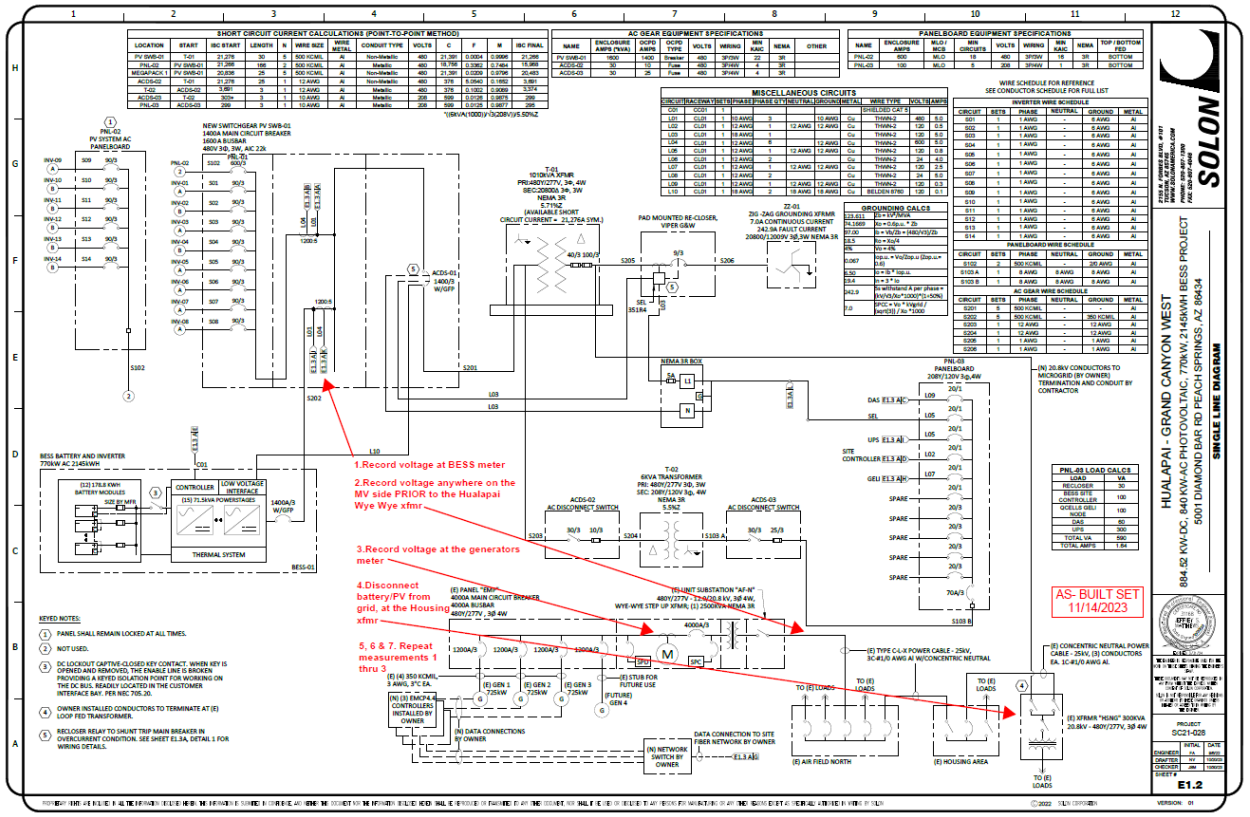
Failure of Zig-Zag Transformer on July 18, 2024

- The solar array and battery back-up system worked nearly flawlessly up until the evening of July 18th when the Zig-Zag transformer caught on fire resulting in the solar array/battery system shutting down and the micro-grid being off-line for over 24 hours.
- **What is a Zig-Zag transformer?** The device provides a path to ground the neutral current caused by the load imbalance and drifting voltages on the existing micro-grid.
- Review of the neutral current log showed a **1,625 Amp spike** at 9:39 AM on July 16th which should have triggered a system shut-down prior to the catastrophic fire two days later.
- As a result of the Zig-Zag's failure, the Tesla Mega Pack was left w/ a 10% charge. The battery has since been charged to up 50% via the diesel-energized micro-grid.

Picture of Interior of Zig-Zag Transformer taken a day after the fire.

What Are We Doing To Fix The Problem?

- Solon, in association with Tesla, Caterpillar & HTUA, is currently doing testing and running simulations to determine the cause of the failure and provide a solution given that the equipment and workmanship is their warranty responsibility.



- Proposed solutions range from: 1) installing a new Zig-Zag transformer (52 week lead time) or a rental unit in the meantime, 2) connecting the 14 inverters directly to the micro-grid and by-pass the Mega Pack, and 3) replacing the main Delta-Wye transformer with a Wye-Wye transformer.

Summary - Next Steps – Major Take Aways

- Setup system monitoring to alert users of potential problems.
- Resolve any system design issue prior to developing Phase 2.
- Work on optimizing system to minimize fuel consumption.
- Increase load on micro-grid to reduce PV curtailment through grid expansion and/or by deploying EV charging *(working with NREL to electrify GCW circulator bus route).*

- Battery resolved a significant technical problem – battery absorbs excessive VARs produced by the micro-grid.
- Retain qualified personnel: HTUA Generation Manager is a 4-year degreed electric utility and communications engineer.
- Be sure to adequately budget for the replacement of the main battery. Battery should be replaced in about 9 years.

Questions?
Thank you for your time!

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