Alaska Department of Transportation & Public Facilities

Off-grid Power for ITS – Moving To an Efficient, Resilient, and Green Future

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Off Grid Power for ITS

- Motivation
- Challenges
- Power analysis
- Off-grid power solutions
- Findings
- Outcomes
- Recommendations
- References

Motivation

- RWIS locations - in significant reporting locations but off grid
- Off grid power - lines too costly / unrealistic to extend
- Performance – resiliency & efficiency:
    - Internal combustion generator – maintenance & parts
    - Fuel cell - excessive maintenance
    - Electrical components – draw on power
- Footprint – environment friendly with GHG reduction

Challenges

- Infrastructure cost @ 7 sites – leverage existing propane tanks, infrastructure, electronics
- Power needs – 50 W not large but significant for remote operations
- Component power consumption – reduce budget for sensors, cameras, communication
- Power conversion – eliminate to extent possible
- Heated equipment - tipping buckets, cameras

Power Analysis- Evaluation Approach

- Current power requirements - sensors, cameras, communication equipment, & electronics
- Alternatives - based on needs, climate, & availability
- Improvements - weather sensors, cameras, & communication equipment
- Findings - energy budget to meet power needs
- Operating scenarios - to reduce power consumption

Power Requirements - Current

Device	Power Consumption
Remote Processing Unit Line powered Linux RPU	No sensors - 11.5 W Max – 50 W @ +12 V Max – 110 W if all sensors are drawing at once
Wind RM Young 05103-L RM Young 05106-MA RM Young 58000 Ultrasonic	 0.36 W 0.48 W 0.36 W
Cameras AXIS P1343 Network Camera Cohu 8546 Color Camera Cohu iDome PTZ Camera	 6.4 W, 12.8 with heater 13 W, 27 with heater 27 W, 104 W with heater
Temperature/RH Sensor: Theis	1.5 W
Yes / No Precipitation Sensor	0.78 W

Power Requirements - Current

Device	Power Consumption
Pavement Sensors & Temperature Probes	0.01 W
Snow Depth Sensor: Judd Ultrasonic	0.06 W
Precipitation Gauge: Nova Lynx 260-2500	3 W, 400 W with heater
IR Illuminator (Cantronix)	Max – 55 W
Communications: KU-band transmitter	25 W

Power Analysis - Alternatives

- Fuel Cells:
  - Acumentrics RP500 – propane / 500W
  - Efoy Pro 800 – methanol / 45W
- FAA Aviation Weather Camera program:
  - APRS World WT-10 Wind Turbine – 1kW
  - Global 5060 Thermoelectric Generator – propane / 50W
- Solar Panels – state of the science
- Electronics & Communication - simplification

Power Consumption - Improvements

Device	Power Consumption
CR6 Datalogger	No sensors - 11.5 W, operational to 50W Max – 110 W if all sensors are drawing at once
Temperature/RH Sensor: HMP60	1 mA average, max. peak 5 mA
Communication: Raven X Cell Modem	Dormant - 1.5 W, 2.5 W Receiving/transmitting – 2.5 W
ClearM2M-S Cellular Amplifier	Idle – 3 W, Operating – 12 W
<u>Cameras</u> Axis 1357-E Mobotix M15 Mobotix M24	 12.95 W or High PoE max 25.5 W < 4.5 W 6W, 12 W heated
<u>Remote Monitoring</u> Sixnet ET-5ES Ethernet Switch Remote Monitoring System RMS-300	 Max - 4 W 1.2 W

Power Analysis - Findings

Demand Analysis (Continuous Operation): Seward Highway @ Turnagain Pass MP 69.9						
Month	Current Energy Demand (kWh)	Energy Demand After Replacing Cameras and Communications Equipment (kWh)	Energy Demand After Incorporating Solar & Wind (kWh)	Energy Demand: Solar,Wind & Acumentrics Fuel Cell (kWh)	Energy Demand: Solar, Wind & Efoy Fuel Cell (kWh)	Energy Demand: Solar, Wind & Thermoelectric Generator (kWh)
January	109.7	22.6	12.6	-359.3	-20.8	-27.5
February	93.5	20.0	-2.2	-338.1	-32.4	-38.4
March	98.6	21.7	-32.6	-404.5	-66.0	-72.7
April	56.2	18.0	-69.7	-429.5	-101.9	-108.4
May	52.4	18.1	-100.1	-472.1	-133.6	-140.3
June	50.7	17.6	-109.8	-469.8	-142.2	-148.6
July	52.4	18.1	-98.2	-470.2	-131.6	-138.3
August	52.4	18.1	-75.4	-447.4	-108.9	-115.6
September	50.7	17.6	-42.1	-402.0	-74.4	-80.9
October	59.8	18.7	-14.6	-386.5	-48.0	-54.6
November	106.1	21.9	7.9	-352.0	-24.4	-30.8
December	109.7	22.6	16.9	-355.0	-16.4	-23.1

Power Analysis - Findings

Power Source	Power Capacity (W)	Capital Cost ($)	Fuel Gas Rate (gal/kWh)
Stion STN130 Thin Film Solar PC Panels	130 W	$105 ea	NA
APRS World WT-10 Wind Turbine (24V with rectifier)	75 W @ 40 mph & 12 VDC	$4,000	NA
Acumentrics RP500 Fuel Cell	500 W @ 12 VDC	$28,531	0.12
Efoy Pro 800 Fuel Cell	45 W @ 12 VDC	$21,500	.24
Global 5060Thermoelectric Generator	40 W @ 12 VDC	$6,500	1.16

Power Analysis - Findings

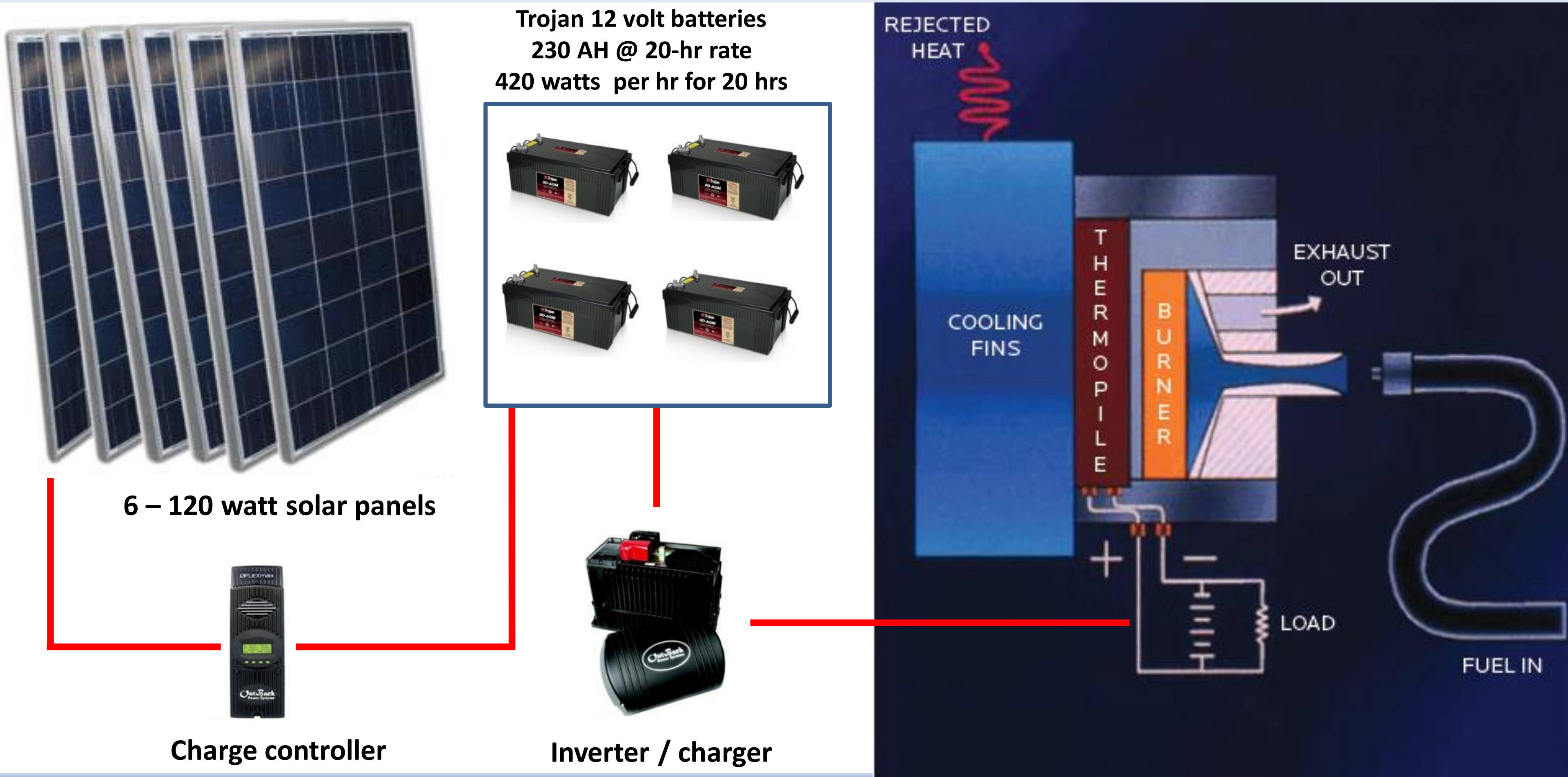
- Two upgrade options:
  - TEG + solar panels = FAA model
  - Solar + wind*
- Cameras - Power-over-Ethernet (POE)
- Communication equipment – reduced power
- Wind generator* – limited applications

Power Analysis - Findings

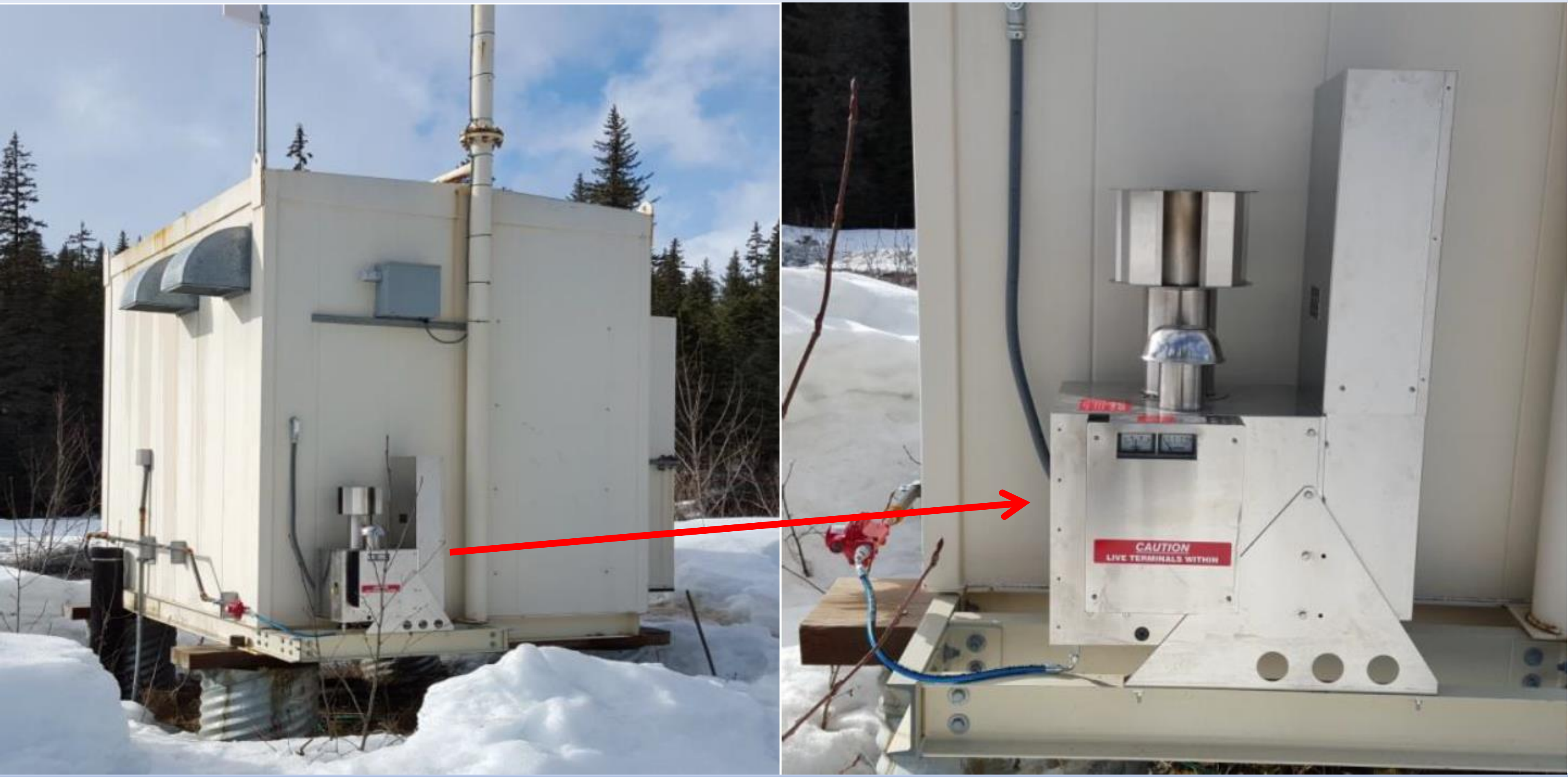
- Heated equipment:
  - Replace cameras with POE non-heated cameras
  - Replace heated tipping buckets with present weather detectors

- Operating scenarios:
  - Limit camera images to daylight only
  - IR illuminator timer for images

TEG + Solar Panel Solution

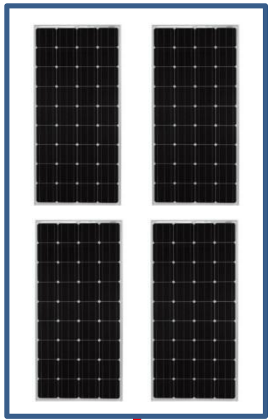


TEG + Solar Solution



Solar / Wind Generator Solution

Carmanah CTI-160 solar panels
160W 12 volt solar panels



Trojan 6 volt batteries
200 AH @ 20-hr rate
420 watts per hr for 20 hrs

APRS World WT10
Micro Wind Turbine *

Charge Controller

Rectifier

* Produces power @ 4.5 m/sec

Solar + Wind Solution

Outcomes

- Reliability - meets or exceeds all the power output and consumption projections
- Resiliency - no downtime related to TEG except for annual maintenance
- Efficiency – TEG propane @ 300 gal/year
- GHG emissions:
  - Minimized leakages
  - Cleaner burn compared to internal combustion
  - Reduced GHG: CO_2, N_2O, CH_4, SO_2

Recommendations

- Upgrade Outback solar charge controller & integrate into remote power monitoring
- Remove absolute devices, relays, and circuit boards that are not being used that may be a power draw
- Schedule annual routine maintenance plus 6 month check
- Add battery storage and a second TEG for additional sensors, IR illuminator, or cameras
- Replace heated tipping bucket with present weather detector
- Complete an energy audit to fully understand the solar & TEG energy production and sensor energy consumption

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