

Outdoor Accelerated Testing of PV Modules

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Sandia National Laboratories



Energy Materials Network
U.S. Department of Energy

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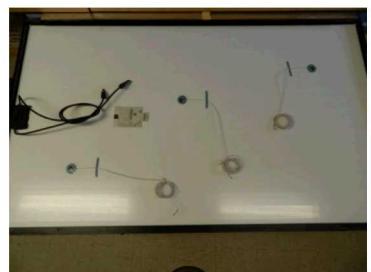
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Outdoor Accelerated Testing of PV Modules - SPARK

Joshua S. Stein – Sandia National Laboratories

Demonstration Project Areas

- **Low-cost accelerated testing of full sized modules**
- Multi-stressor acceleration demonstration on four modules
 - 1. Reference module
 - 2. Insulated back
 - 3. Insulated back with active heating
 - 4. Active heating and humidity
- Modules flash tested and EL imaged at start of test



RTDs on module backsheet



Heater blankets installed behind module

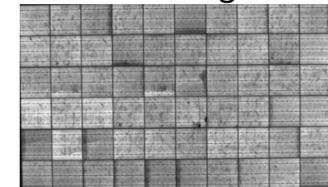


Insulation and backing over heat blankets

Technology Summary & Impact

Update and Status:

- Four Solar World 260 W poly modules selected
- Modules flashed, EL and UVF imaged before testing
- RTDs, insulation, and heaters installed
- Module 1-3 deployed and grid connected
- Module 4 setup (heat and humidity) is being developed

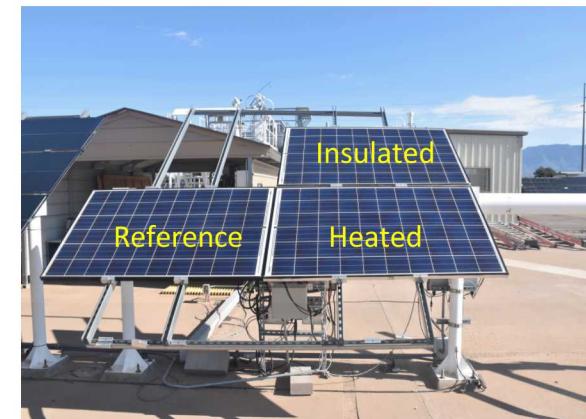


EL image

Back view with three modules installed



Front view with two modules installed



Capability Area & Teaming

Capability Area(s): Accelerated Testing

Team: Craig Carmignani, Craig One Feather, Doug Robb, Don Ellibee, Charles Robinson

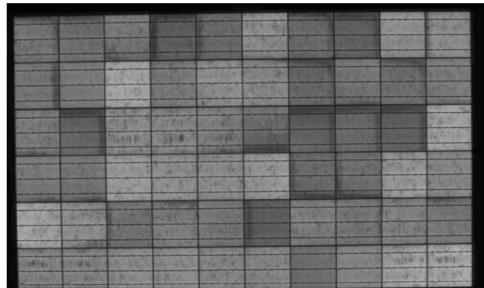
Resources (\$)

Period of Performance: 9 Months

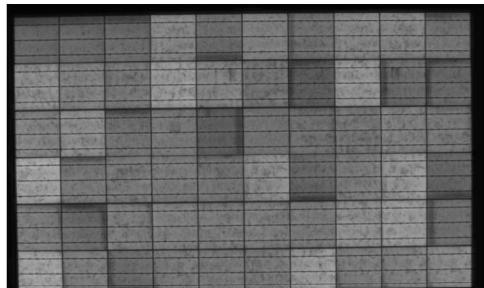
Total Budget (per year): \$50,000

Initial Module Characterization

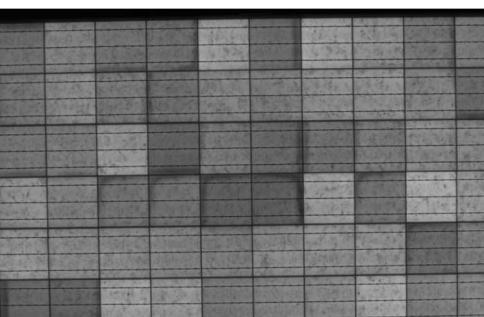
EL (6/3/2019)



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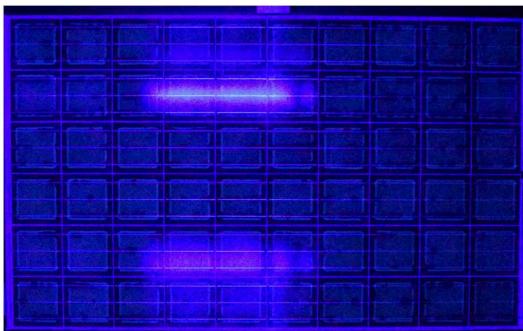
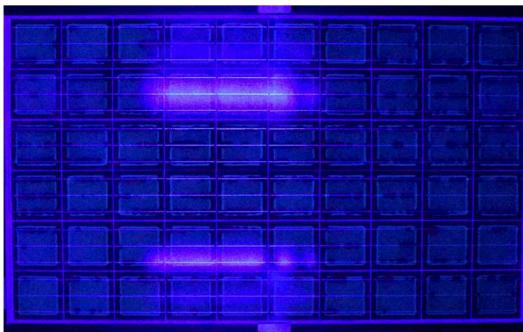
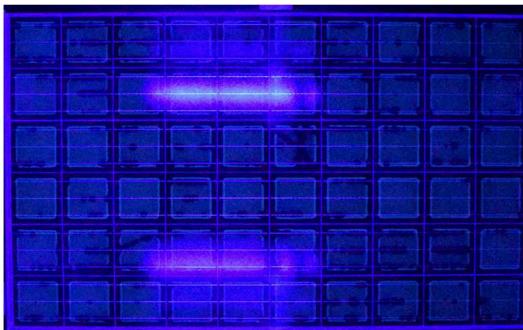


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UVF (6/10/2019)



Flash Tests (5/20/2019)

- $P_{max} = 257.3 \text{ W}$
- $I_{sc} = 9.05 \text{ A}$
- $V_{oc} = 37.4 \text{ V}$
- $I_{mp} = 8.54 \text{ A}$
- $V_{mp} = 30.1 \text{ V}$

- $P_{max} = 256.5 \text{ W}$
- $I_{sc} = 9.01 \text{ A}$
- $V_{oc} = 37.3 \text{ V}$
- $I_{mp} = 8.52 \text{ A}$
- $V_{mp} = 30.1 \text{ V}$

- $P_{max} = 256.8 \text{ W}$
- $I_{sc} = 9.04 \text{ A}$
- $V_{oc} = 37.3 \text{ V}$
- $I_{mp} = 8.54 \text{ A}$
- $V_{mp} = 30.1 \text{ V}$

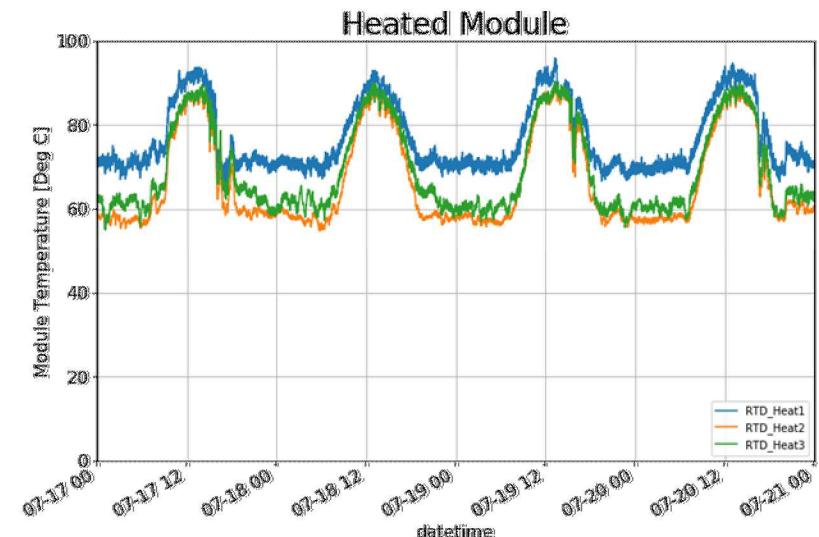
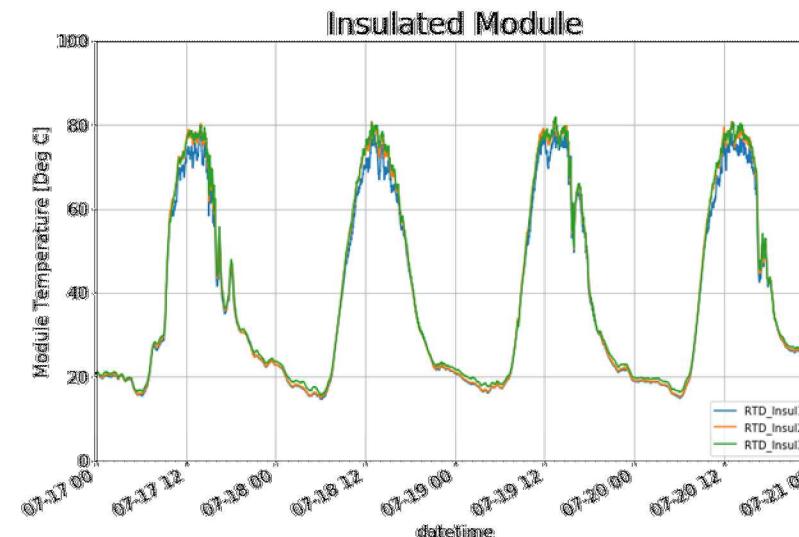
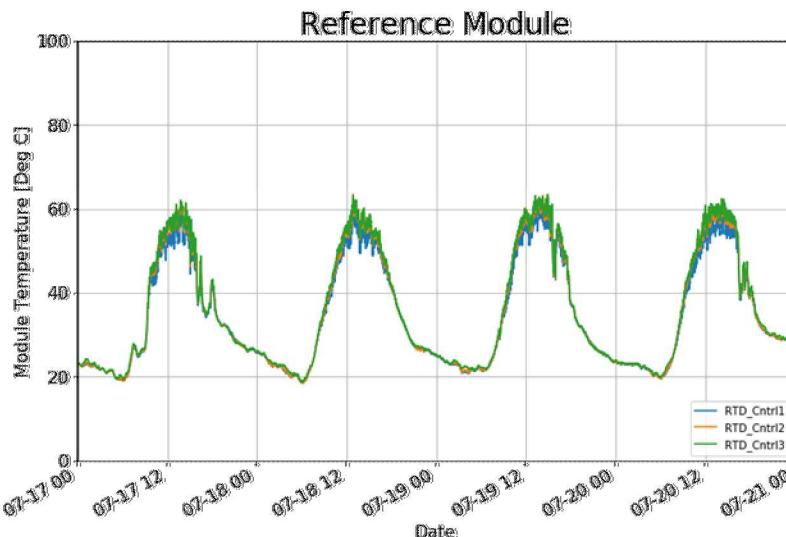
Initial Accelerated Module Temperature Results

Test data collected since July 11, 2019 (38 days analyzed)

- Reference module exhibits max temperatures of ~60 deg C
- Insulated module exhibits max temperatures of ~85 deg C
- Insulated and heated module reaches max temperatures of ~95 deg C
 - Heater also increases temperatures at night from ~20 deg on the reference to between ~60-75 deg in the heated module.
- Heated module does exhibit variability in the measured temperatures
 - May be due to uneven thermal contact between heater and back of module.

Average Module Temperatures (including night)

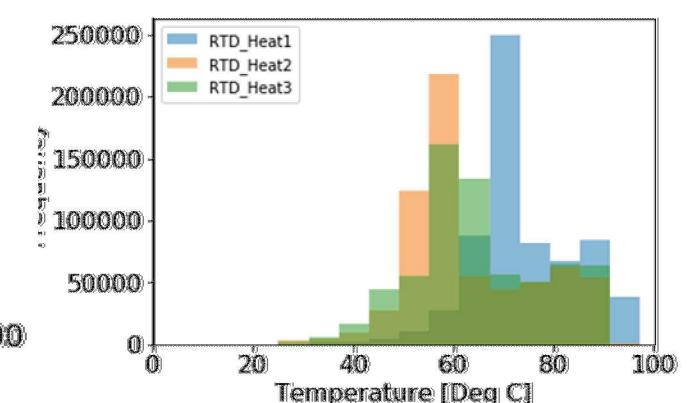
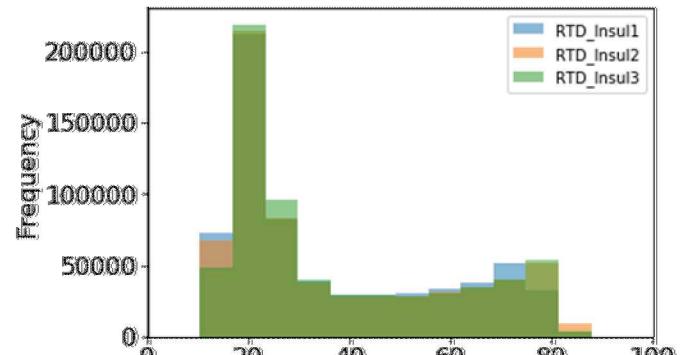
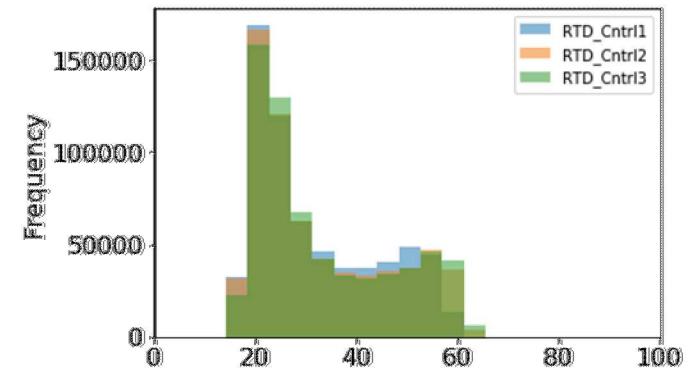
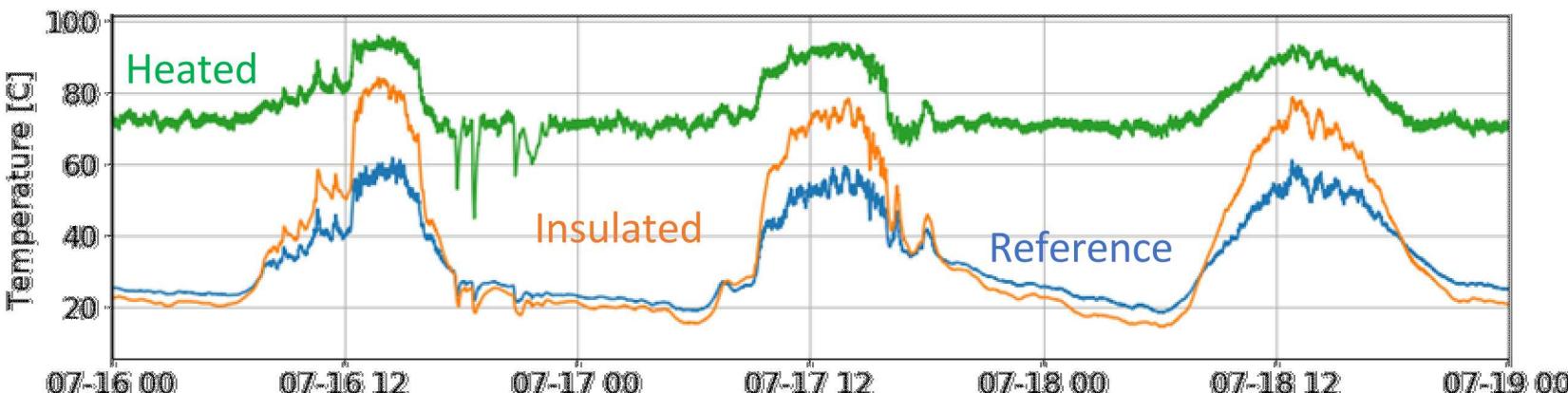
Sensor	Reference	Insulated	Heated
RTD1	31.9	36.1	73.7
RTD2	32.6	37.0	63.3
RTD3	33.1	37.1	64.9



Initial Accelerated Module Temperature Results

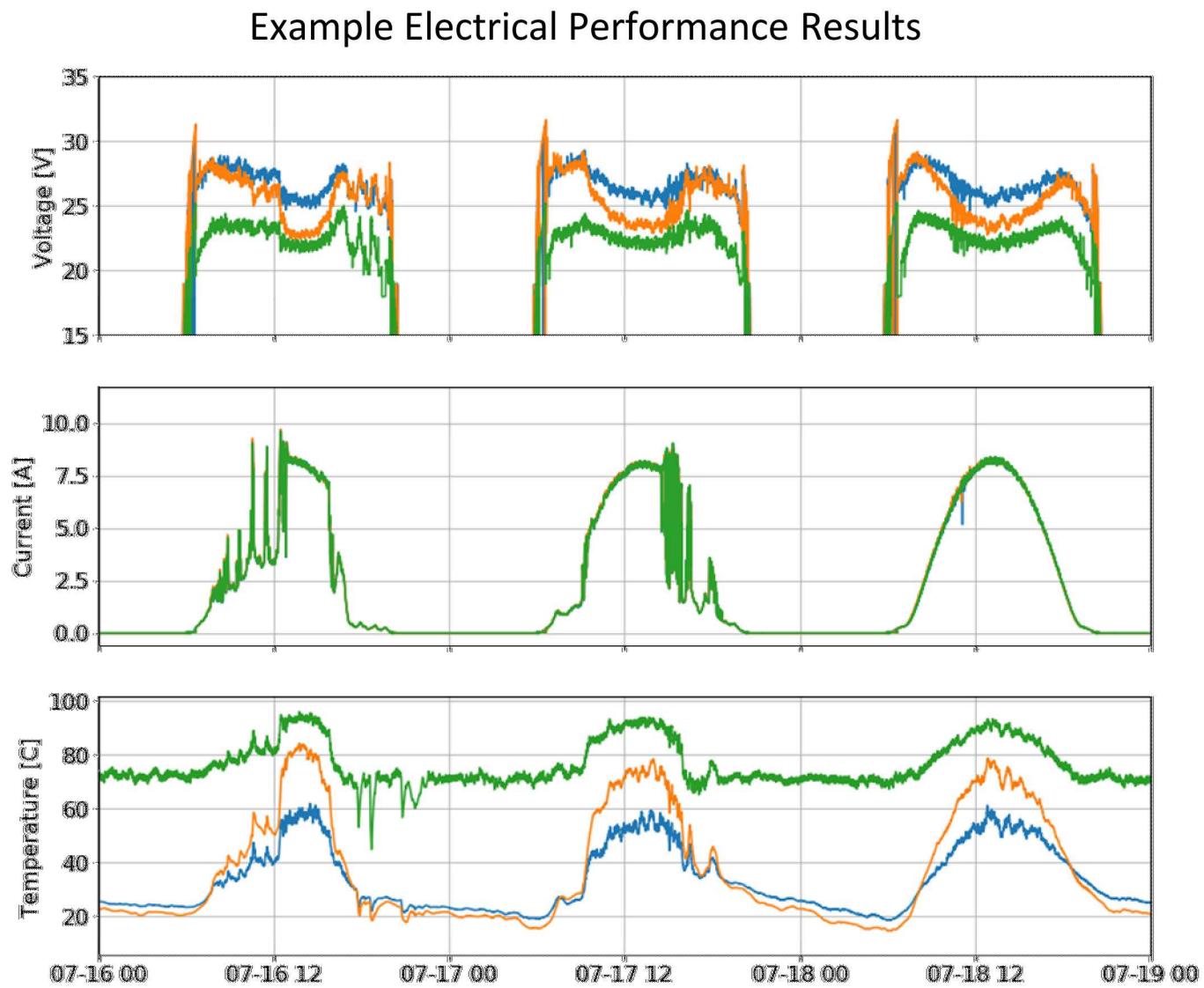
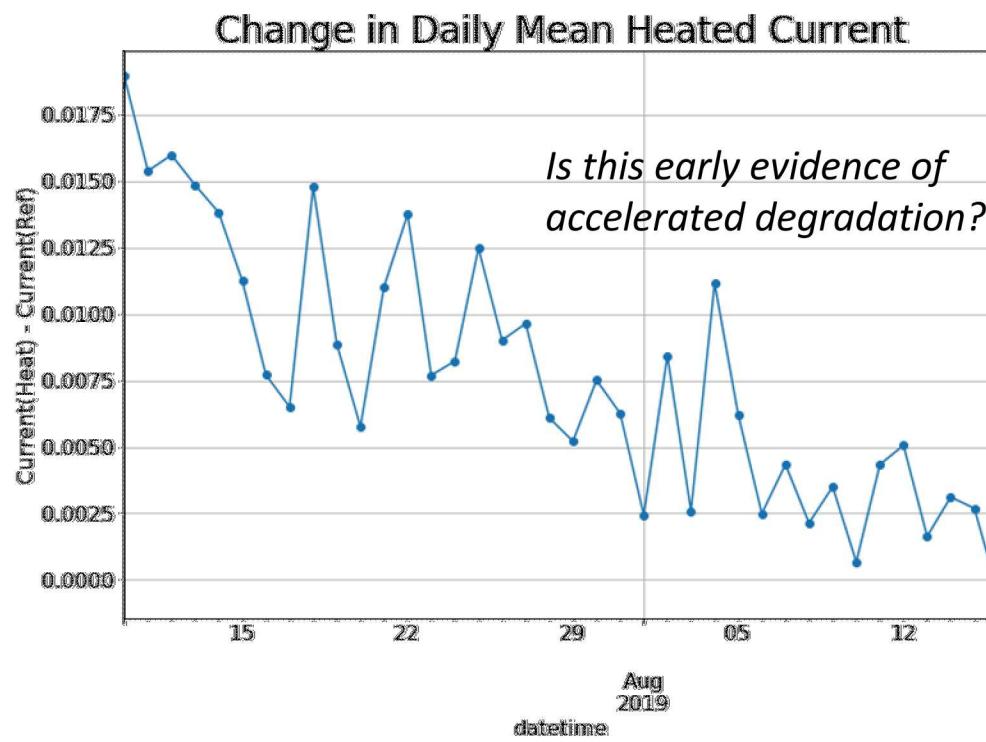
Histograms of module temperatures over 38 days

- Insulation only increases temperature during the day when sun is shining.
- Insulation also decreases temperature at night time (effect of radiance to cold sky)
- Heated module has increased temperatures all the time
- Heated module temperatures are not as uniform.



Initial Electrical Monitoring Results

- Elevated temperatures result in lower measured voltage, as expected.
- Daily average current in the heated module appears to be decreasing faster than the reference module.



Next Steps and Issues

- Project has reached its budgetary limit of \$50k.
 - **Re-scoped from an initially proposed project budget of \$250k.**
- We have completed 3 out of 4 of the module deployments (due primarily to use of student labor)
- Elevated humidity module is nearly complete
 - Chamber is built, needs to be painted
 - Equipment (heaters, pump, tank, sensors) are purchased but need to be installed.
- Sandia will use some of its DuraMAT management budget (\$4-5k) to complete the work.

