Alternative Configurations to Optimize Lead-Acid Batteries for Renewable Generation and Storage (RGS)

DOE Program Review, 10/30/2003

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Project funded by the US DOE ESS Program
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Work performed under contract with Sandia National Labs
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Headlines for FY03

- Continued and expanded testing of 10kW Class (Type A) Units
- Improved ACONF technology, tested “in field” with Type A Units
- Developed and performed preliminary testing of 100kW Class (Type B) Units
- Made first “sale” of technology to USCG and prepared for ensuing test program

Alternative Configurations to Optimize Lead-Acid Batteries for RGS

Project Goal

To conceive, develop, and promote implementation of, alternative configurations for renewable generation and storage systems that will improve reliability, enhance component performance, and lower life-cycle-costs

Secondary Goal

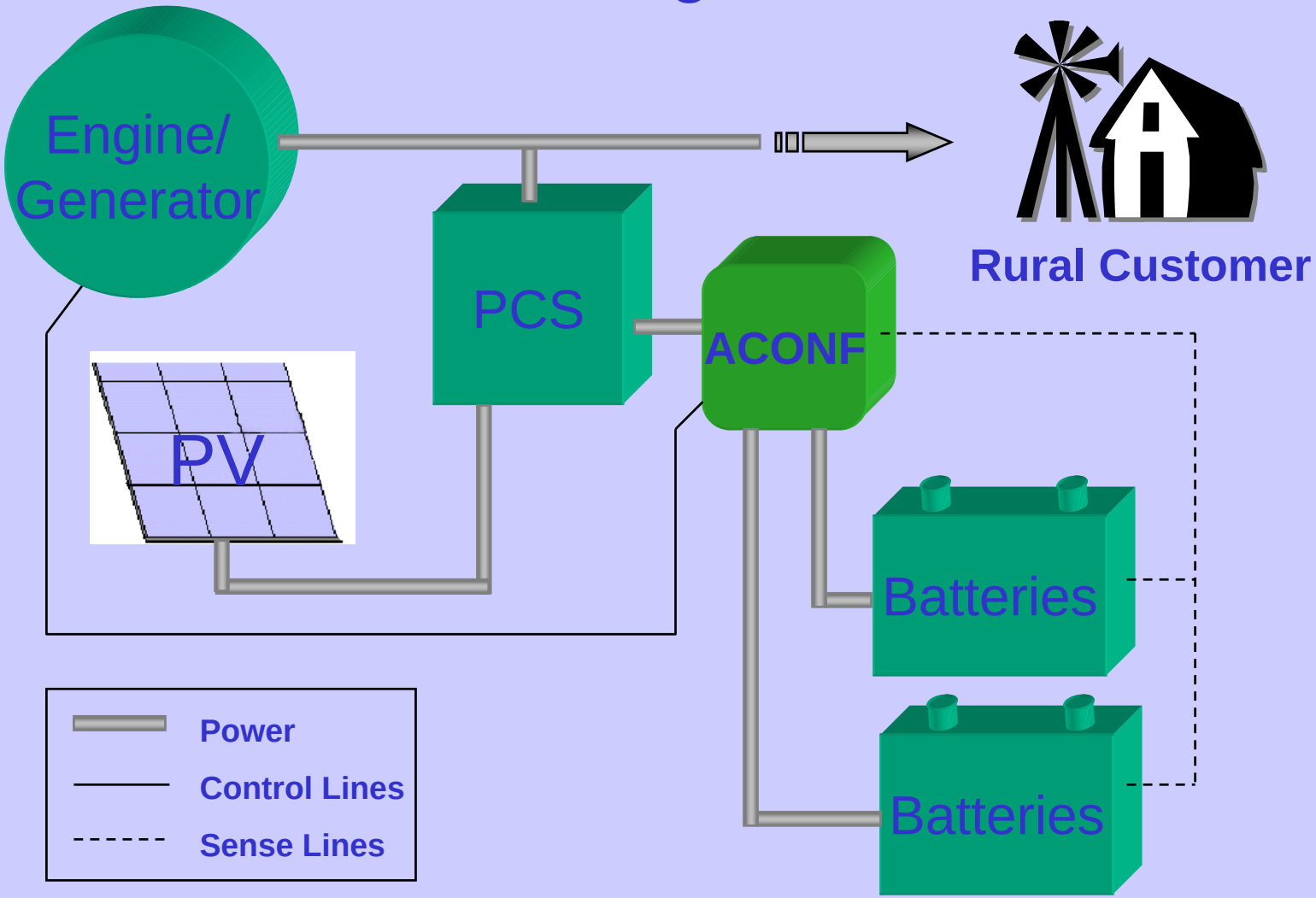
To facilitate communication between battery manufacturers and RGS users, using the alternative configurations developed, so that batteries might be used to their best advantage without compromising system performance

What are RGS Battery Alternative Configurations?

- Added circuitry between each string of the battery and the DC terminals of the AC-DC-AC converter
- Hardware and software to control the currents to and from the strings through the additional circuitry

The string currents are controlled on the basis of measured parameters and the characteristics the battery modules used in each specific installation

What are RGS Battery Alternative Configurations?



Project History/Approach

- **FY98: Conceptualized solutions to RGS problems**
  - **Batteries do not perform or live as expected**
  - **Batteries require maintenance charges using generator**
- **FY99-00: Developed alternative configurations (ACONF) as solution, with first modeling, then lab testing to confirm validity**
- **FY00-01: Identified user field test site; refined hardware and software; fabricated breadboard and tested in lab and then at field test site**
- **FY02: Patent issued. Identified implementer and performed joint engineering development; built several prototypes and operated at field test site**

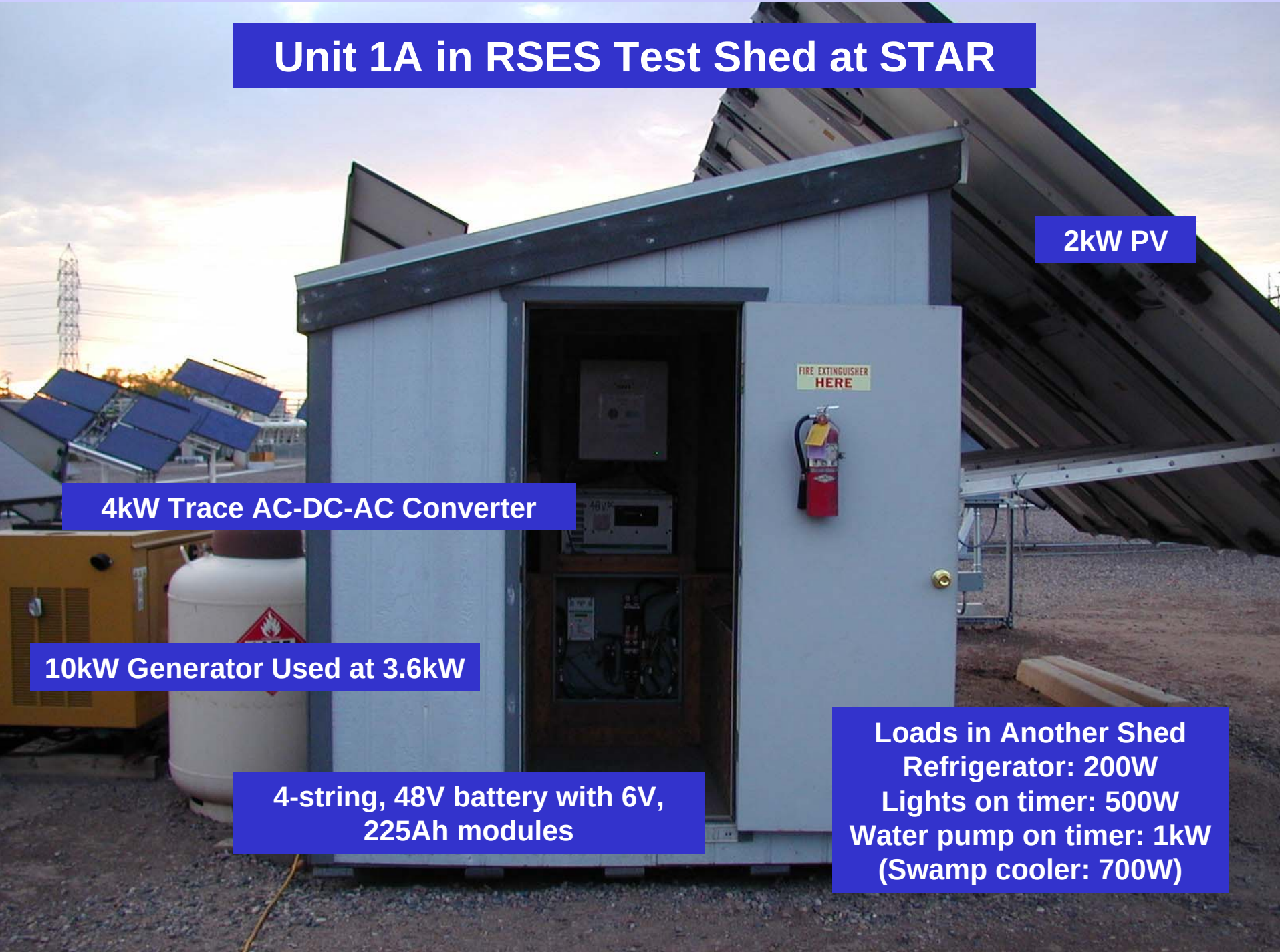
Benefits of Alternative Configurations For RGS Solar Hybrid Systems

- Overcharge and over-discharge avoided
- Battery finishing charge & generator “de-coupled”
- Can utilize PV for and while finish charging
- Easily made smart relative to expected load & solar
- In advanced ACONF units now under development
  - Module voltage and/or temperature used to control charge, finish charge, and discharge
  - Generator will start for weakest module(s)
- Opportunity to maximize battery and system life, performance, and to minimize life-cycle-cost

FY03 Progress: Continued and expanded testing of 10kW Class (Type A) Units

- Testing of Unit 1A, with 48V, 4-string, flooded L/A battery at STAR, continued through year; minimal interruptions in testing because of issues unrelated to ACONF
- Testing of Unit 2A , with 48V, 4-string flooded L/A battery at STAR, initiated late 2002, and continued sporadically; interruptions mostly unrelated to ACONF
- Testing of Unit 3A, with 24V, 4-string Absolyte IIP battery at SNL-PSEL, started late in 2002, proved reliable operation and proper recharge of VRLA in several round-the-clock tests each many weeks long
- All of above in preparation for field tests; working to develop Industry Partners for these tests

Unit 1A in RSES Test Shed at STAR



2kW PV

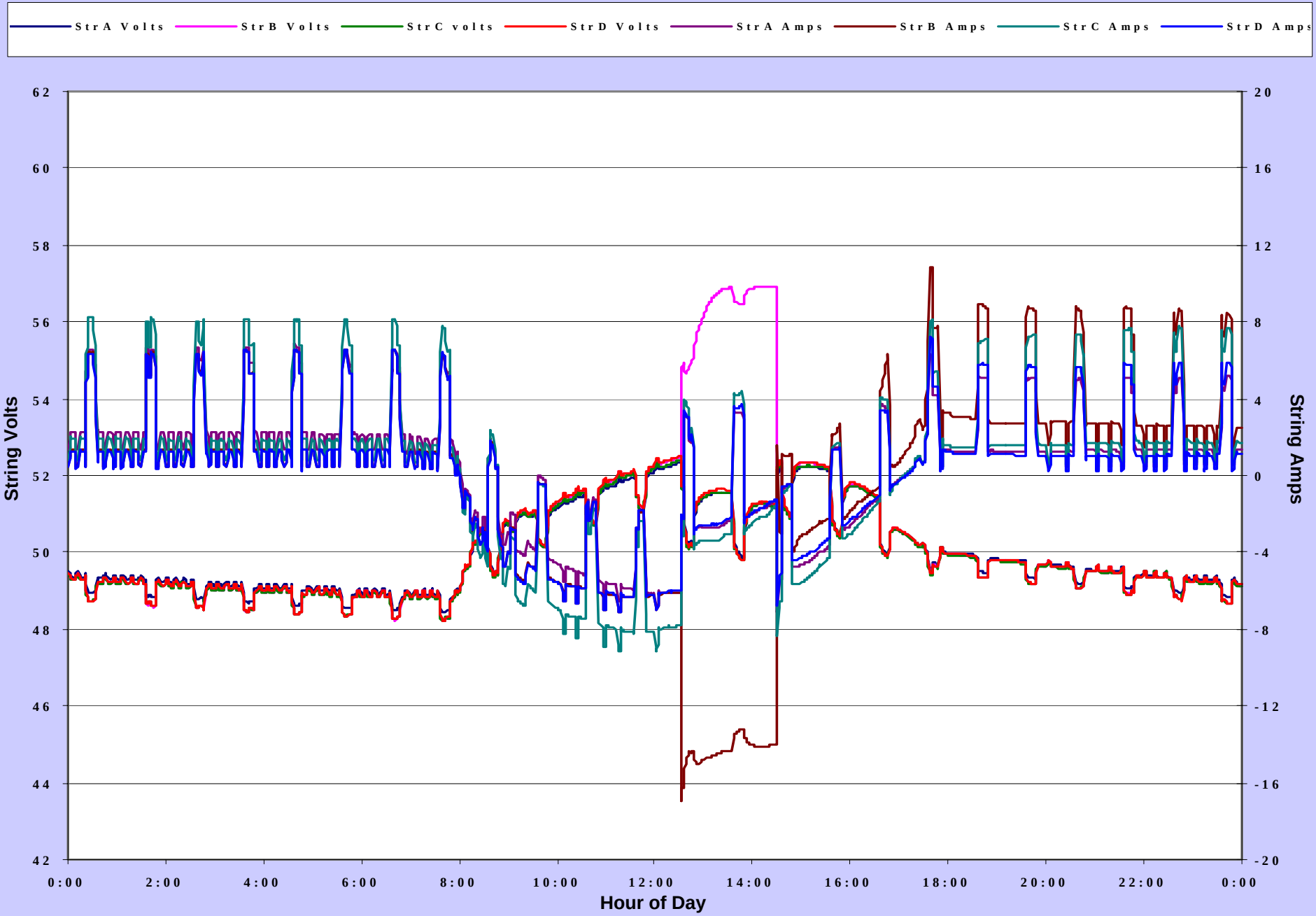
4kW Trace AC-DC-AC Converter

10kW Generator Used at 3.6kW

4-string, 48V battery with 6V, 225Ah modules

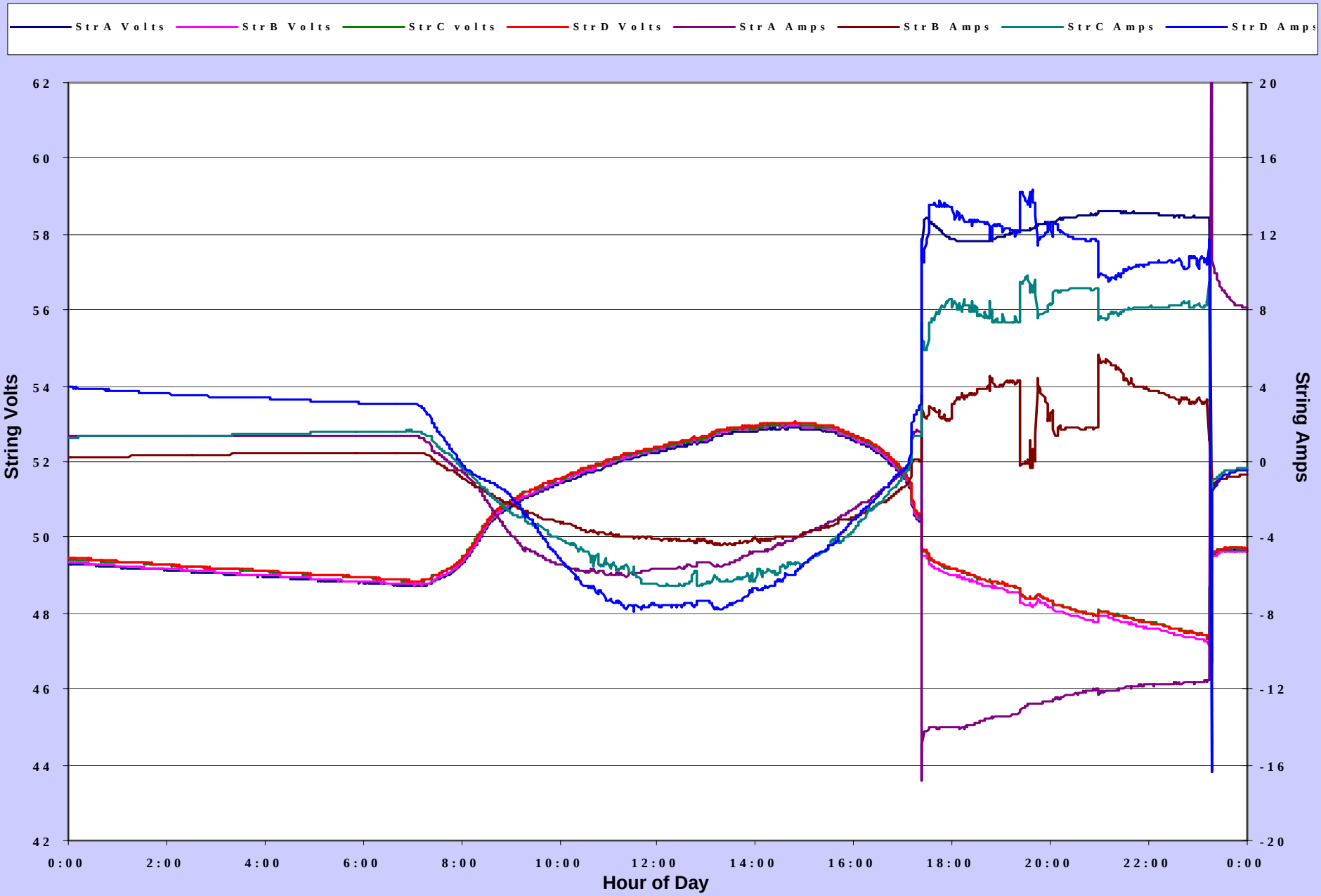
Loads in Another Shed
Refrigerator: 200W
Lights on timer: 500W
Water pump on timer: 1kW
(Swamp cooler: 700W)

ACONF Unit 1A, 10/17/03- Finish Charge String B during Discharge



ACONF Unit 2A at STAR

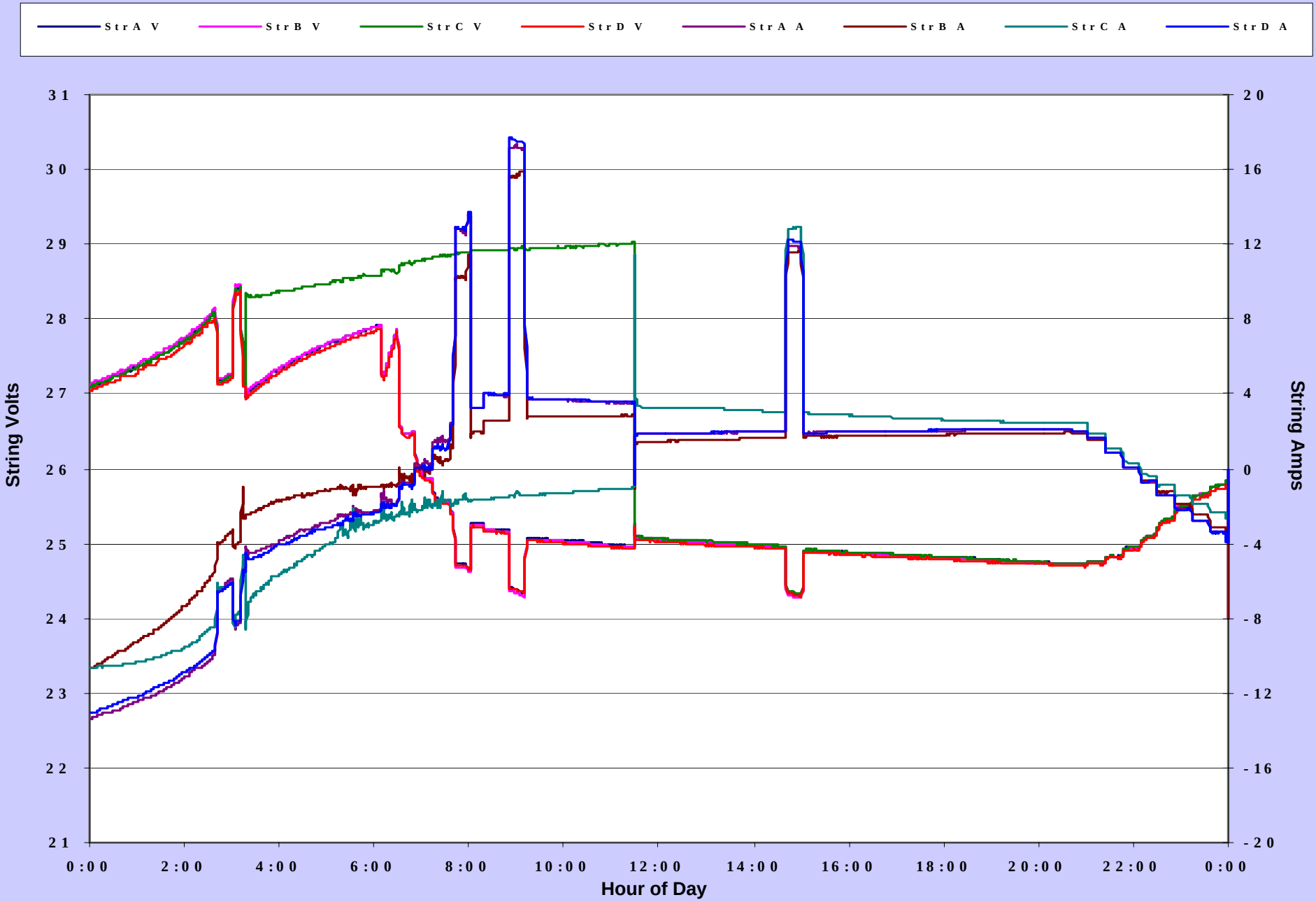
ACONF Unit 2A, 10/19/03- Finish Charge String A during Discharge



Unit 3A at Sandia PSEL

- 4-string, 167Ahr/string, 24V VRLA battery
- Characteristics of battery (capacity, finish charge requirements) established before ACONF testing
- Power supplies to simulate generator and PV array
- Active load bank set up with fixed load with occasional peaks
- Under evaluation since 12/02 with several test sequences each weeks-long in duration

ACONF Unit 3A, 7/18/03- Finish Charge String C after Charge



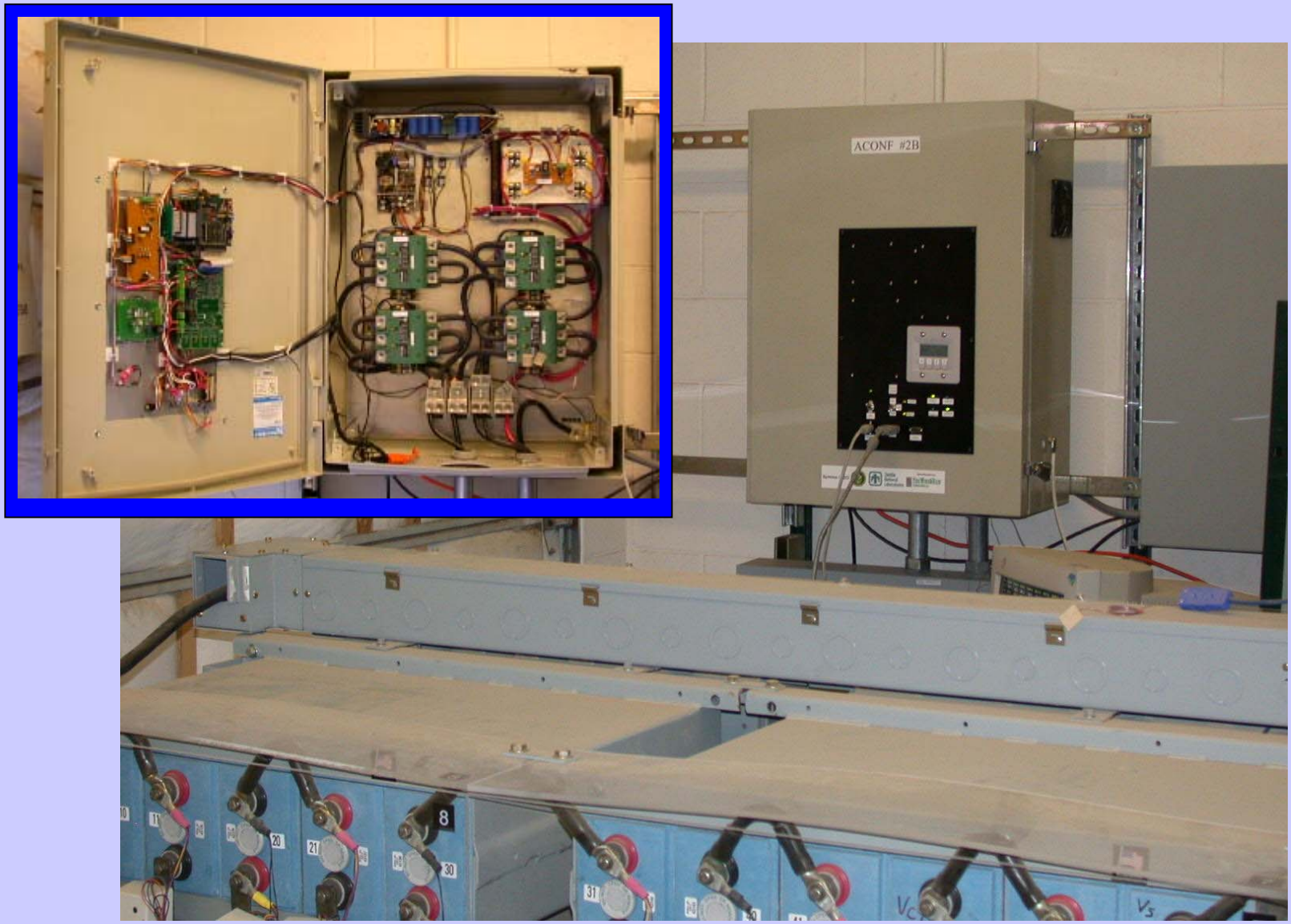
FY03 Progress: ACONF Improvements being Evaluated on Type A Units at STAR

- **Module voltage-temperature sensors**
  - Sense low, high voltage, high temperature
  - Send signals to ACONF unit for action
- **Bypass switch for ACONF malfunctions**
  - Industry partners feel these necessary
  - Activate on low voltage or comm failure

FY03 Progress: 100kW Class Unit 2B Under Test at Sandia DETL

- 2-string, 425Ahr/string, 240V Yuasa Gel VRLA battery previously tested at STAR
- Trace (Xantrex) 30kW converter connected to grid for charging; solar arrays also available
- Variety of load banks can be connected to Trace output
- ACONF unit sized for 33kW/string (100kW for 4-string unit)
- Preliminary testing underway to evaluate innovative (low-cost) finish charge approach

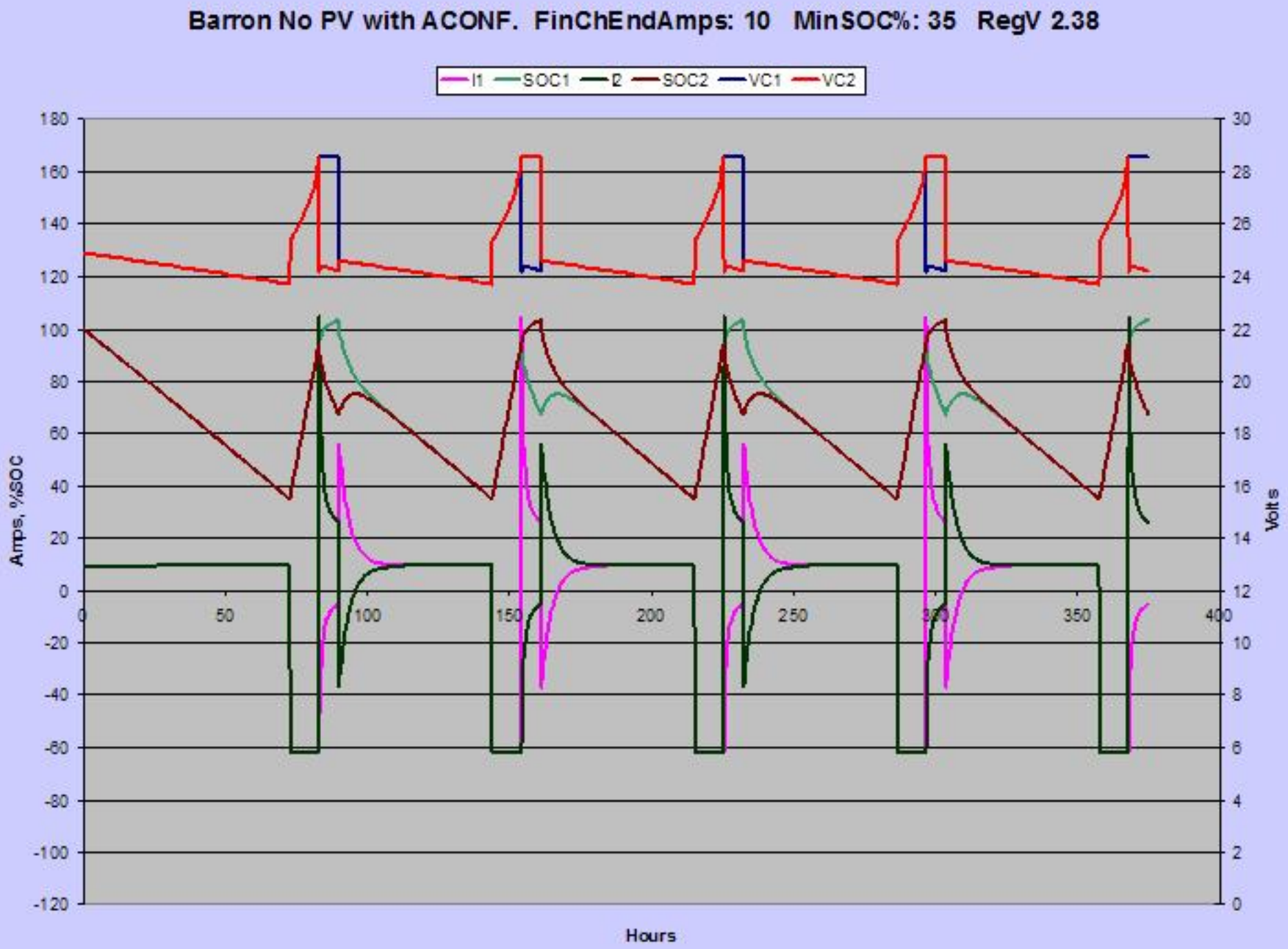
ACONF Unit 2B at SNL DETL



FY03 Progress: “Sale” to USCG for NDS Remote Hybrid Power Application

- National Distress System (NDS) sites
  - Remote, mountaintop locations
  - Fuel, battery replacements very expensive
- Require highly reliable power
  - Robert Barron site: 460 watts, 19 amps
  - Duke Island site: 350 watts, 14.4 amps
- Power system consists of following
  - PV array providing some of annual energy requirements
  - Propane generator with charger/controls: 160 amps
  - Absolyte IIP Battery: Two 24V strings of 1065Ah cells
  - Taper to 31amps at regulation, versus 10amps desirable

Modeling performed with DOE funding to determine potential applicability of ACONF technology to USCG NDS Application


Barron No PV with ACONF. FinChEndAmps: 10 MinSOC%: 35 RegV 2.38
I1
SOC1
I2
SOC2
VC1
VC2
Amps, %SOC
Volts
Hours
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
250
300
350
400

USCG Modeling: 10amp finish + PV

Simulated Cycling to 50% SOC				
	TestHours	%HrsGenOn	GenStrts/mo	Galls/month
RB W 10finA 50%SOC 238regV GenE	430	16.4	8.5	107
RB W 10finA 50%SOC 238regV ACNF	355	10.4	10.3	87
RB S 10finA 50%SOC 238regV GenE	1242	5.5	2.9	36
RB S 10finA 50%SOC 238regV ACNF	1242	2.7	2.9	24

USCG Project on ACONF

- From modeling, USCG convinced of potential benefits of ACONF for NDS
- USCG to fund 6-month test program at Sandia DETL to prove fuel consumption reduction benefits of ACONF, and to validate reliability of ACONF; DOE to fund supporting work on USCG NDS Project
- USCG Phase I Program will comprise parallel tests of model NDS Power Systems with and without ACONF
- Power systems will include generator + charger +controls with ratings as at NDS sites; synthetic loads to be used
- Symons/EECI with Implementer supplying ACONF Type A Unit with more powerful Finish Charger

Return to Agenda

Next Steps

- Continue testing of ACONF 10kW class (Type A) prototypes
- Cement relationships with Industry Partners and Implementer
- Further develop improved Type A units and arrange field test(s) for these
- Test and characterize 100kW Class Unit 2B, evaluate Unit 3B at STAR Hybrid Test Facility
- Complete development of Unit 1B, perform design work on other 100kW Class sites
- Complete 1st phase of USCG testing, arrange follow-on work with USCG; contact other potential US Government users