
ETO StatCom Project Update

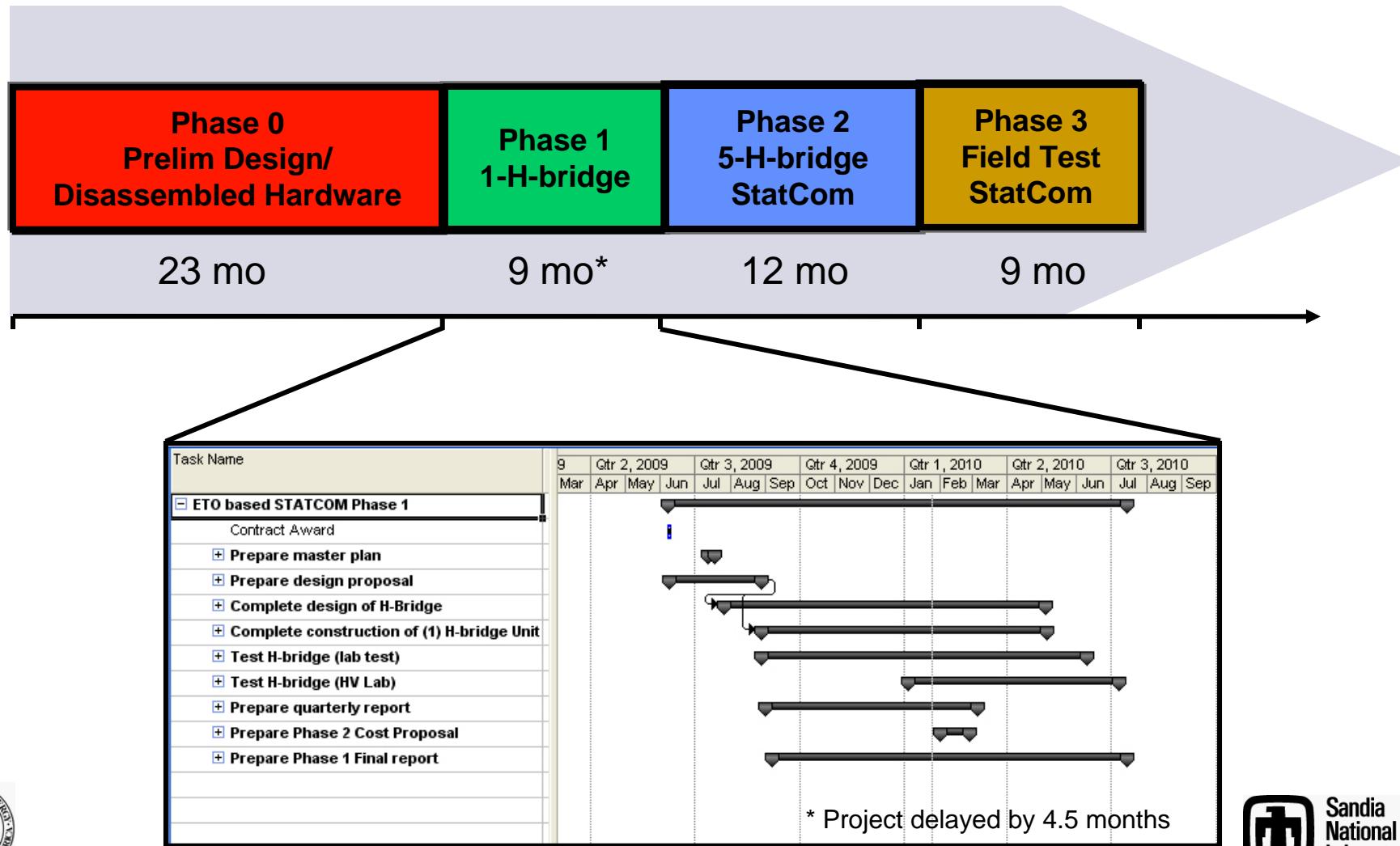
Stan Atcitty, PhD

Sandia National Laboratories
Energy Infrastructure & DER, Dept. 6336
February 03, 2010





ETO StatCom Project Schedule





ETO StatCom Project – Phase 1

Phase 1 Project Duration: 06/08/09 — 07/15/10

Total Project Budget for Phase 1: \$990,378

Spent to Date: \$202,458

SPCO Dollars Leveraged: \$80,301

BPA Lead: Mike Hulse

Sandia Lead: Stan Atcitty

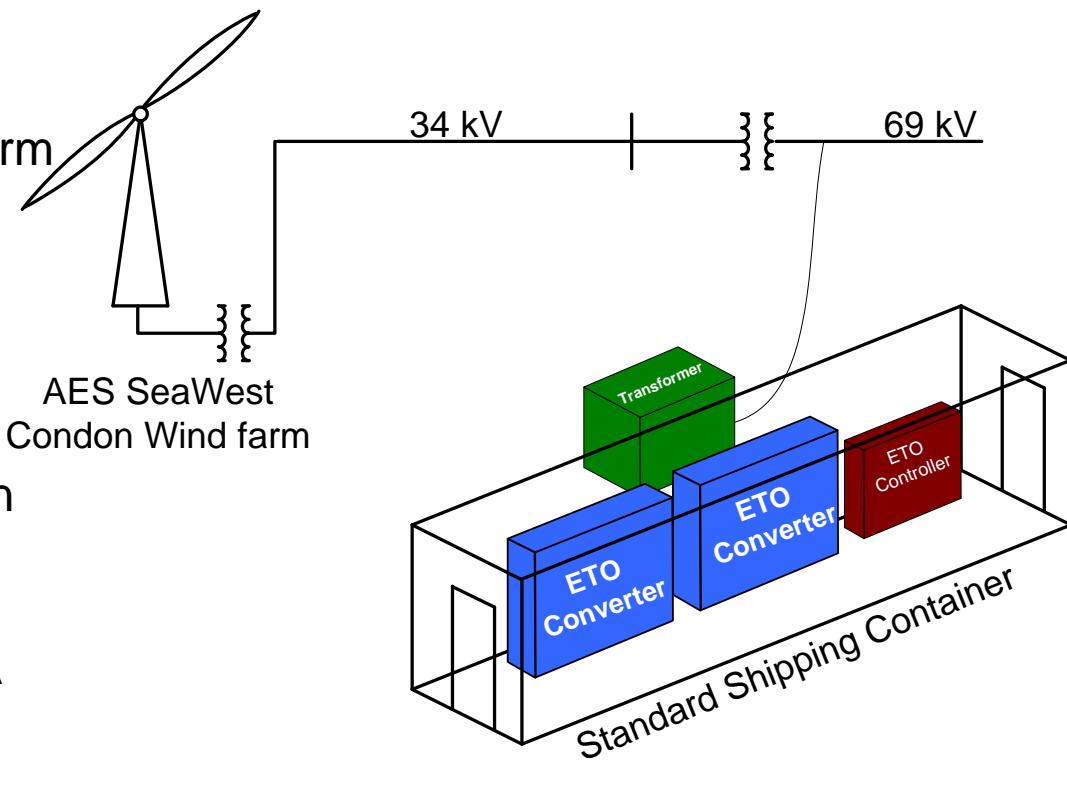
Consultant: Silicon Power Corporation (SPCO)



ETO StatCom Project – Phase 3 proposed*

Funded under the DOE Energy Storage Program: Dr. Imre Gyuk
Sandia Energy Infrastructure & DER manager: John Boyes

- **Issue:** Voltage fluctuations introduced at Condon Wind Farm have an adverse effect on other nearby customers.



- **StatCom Specs:**
- +/- 10 MVA
- Active & Reactive Injection
- DC Bus Voltage = 2170 V
- $V_{pcc} = 4160$ V
- Nominal Current = 1400 A
- Peak Current = 1979 A
- PWM control
- Multilayer Topology

BPA demonstration site TBD*



ETO StatCom Project – Gap Analysis

Appendix 3: Power Electronics Gap Analysis

Existing Products

By Switching Frequency

Slow Switching Frequency Devices

- 1) Silicon Controlled Thyristor - Line commutated Utility Applications are in VAR Compensation, FACTS and HVDC
- 2) GTO Thyristor - Gate Turn off commutated Utility Applications are in VAR Compensation, Power Quality, FACTS, Voltage Source Conversion (VSC)

Medium Switching Frequency Devices

- 1) IGBT - Gate Forced commutation Utility Applications in Power Quality, VSC transmission, Wind turbine generator control, Motor Drives, Inverters
- 2) IGCT - Gate Forced commutation Application same as 1)

High Switching Frequency Devices

MOSFET

No significant utility use. On resistance too large at high current with present Silicon technology.

By System Topology

Slow Switching Topologies

- 1) Line Commutated 60Hz
 - a) Series Thyristor stack for HVDC quadri-valve and SVC systems
 - b) Bi-directional Valves
 - c) Thyristor Controlled Series Compensator systems
- 2) Gate Turn Off Commutated Utility Applications are in VAR Compensation, Power Quality, FACTS (Unified Power Flow Controller),

Medium Switching Topologies

- 1) 2 level Pulse Width modulation Topology
- 2) Multi level Conversion matrix topology (5 levels and greater)

TECHNOLOGY GAPS

Future Products will be founded on new:

Semiconductor devices that are combinations of the best characteristics of present devices. Devices that are analogous to present devices but constructed from high band gap materials (extreme temperature withstand, high current capacity & high voltage withstand). New semiconductor devices that are used in new topologies or novel modulation techniques. Present power electronics that are used in new topologies or novel modulation techniques.

Power Electronics Cooling is *weak point* in most systems.

- Cooling usually involves mechanically driven fluid at high voltage potential.
- Chemical properties of cooling fluid have to be carefully maintained
- High maintenance and needs high reliability auxiliary power sources.

GAP = Minimize cooling demand with new semiconductor material that can tolerate very high internal junction temperatures.

Silicon Carbide	Gallium Nitride	Diamond
-----------------	-----------------	---------

DC – AC forced commutation systems, the tradeoff is - "For the same performance, the fewer the switching levels (hence a simpler device matrix) the faster the power electronics must switch. The slower the switching cycle, the more switching levels are needed and the more complex the multi-level converter becomes.

GAP = Complexity of parallel, series converter matrix to provide both high voltage withstand and high current capability. Solution = a) semiconductors with higher voltage withstand & b) novel multilevel switching topologies

GAP = Inability to control magnitude of fault current on DC side of converter

Present device trade-off's: Voltage withstand and On resistance versus switching speed.

GAP = Material Properties, geometry, doping, purity, gating

SYSTEM COSTS GAP = Lack of Standardization and no mass production

Power Electronics main market is the drives industry (lower voltage levels)

Multi-Terminal HVDC Current Source Converters - All Inverter taps must be rated for full system power regardless of tap need. GAP = Control of Current magnitude under commutation failure

High voltage Power Transformers often required in overall Power Electronic system.

GAP = Solid State Transformation or Elimination of need for isolation / source voltage reduction

High Power Utility DC – DC Conversion will require High Voltage, high frequency power switching devices with low loss.

Future Products

Tri Pole HVDC (Topology advancement and switching device packaging innovation)

Multi-Terminal Voltage Source Converter Overhead line Transmission

Diamond Emitter Technology - Solid State "vacuum tube"

Super Conducting DC Cable transmission Superconducting Storage systems

Power System Grid Control / FACTS systems

Solid State Circuit Breakers and Fault Current Limiters

Distributed Generation / Renewable Resource integration of any none symmetric energy source output into the AC grid.

Control of Energy Storage Systems (Capacitor, battery, flywheel, pressure, SMES)

Power Quality - Flicker mitigation and harmonic suppression

Dynamic Voltage Support

Multi function Transmission Building Block (MTTB) that will combine into an economical universal unit that fulfills many needs at once. (STATCOM)

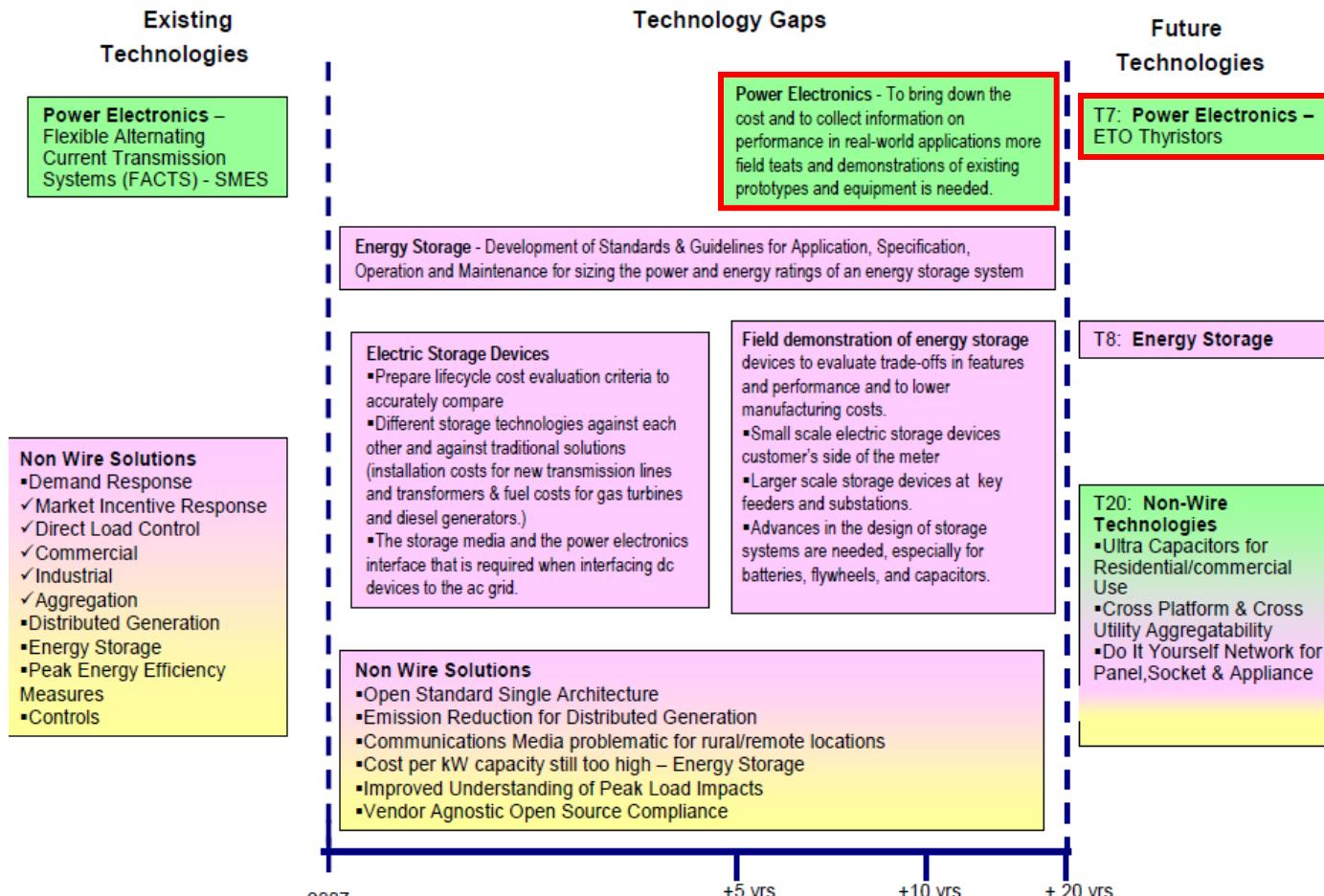
Solid State Transformers

Large Metropolitan DC Distribution systems for workplace DC Power needs



ETO StatCom Project – Gap Analysis (cont.)

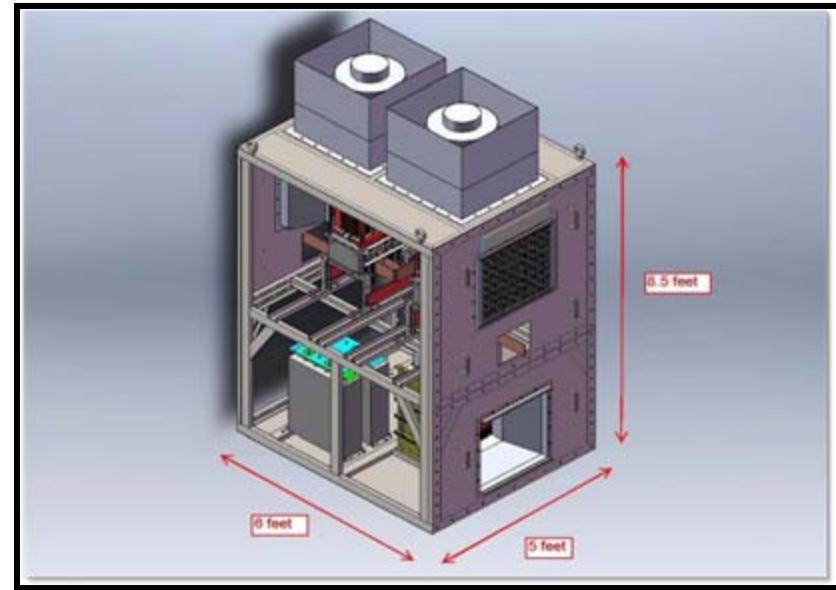
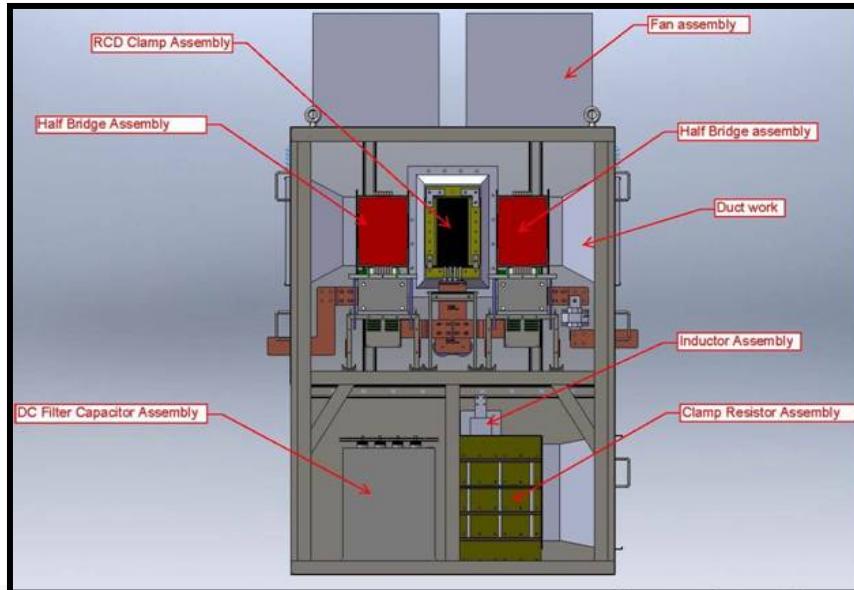
Figure 12: Cost-effective, Environmentally Sound Energy Supply & Demand Gap Analysis





ETO StatCom Status and Milestones – Phase 1

- Four ETO devices were received from North Carolina State University
 - Additional spares will be acquired (each H-bridge requires four ETO devices)
- H-bridge design and simulations completed
- Thermal design of the system is underway (optimization phase)
- Final enclosure design is near complete
- NCSU control design has been reviewed and improvements are being made





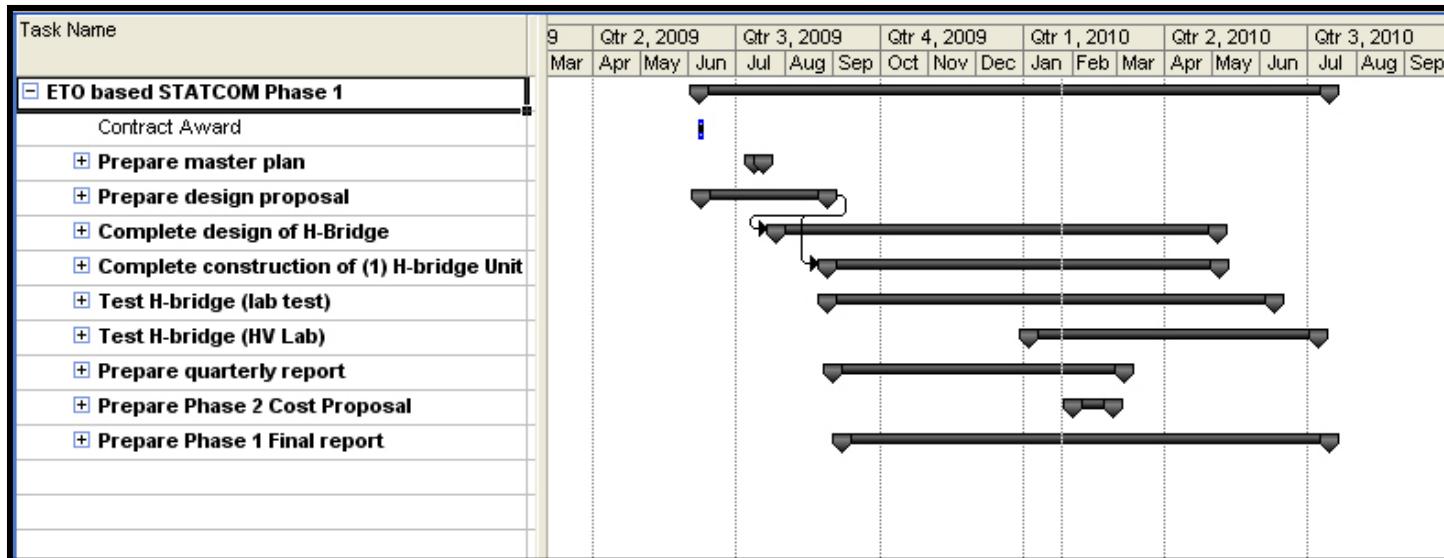
Expected Benefits

- *What does this project actually do for us?*
 - Addresses key technology gaps and future products identified in the BPA Transmission Technology Roadmap using DOE funds for Phase I
 - Provides access to innovative power devices, system & control ideas, and demonstrations
 - Near future support for smart grid distribution and transmission application
 - Provides cost effective reactive power capabilities
 - Provides cost effective modular or ‘cookie cutter’ design
 - Provides long-term cost benefits because the air-cooled system requires less maintenance than a liquid-cooled system.



Summary – Phase 1

- Project is currently on schedule with a new end date of July 14, 2010.
- Project funds are 20% spent through 64% of the project timeline.
- Expect a Phase 2 cost proposal from SPCO in late February





Contact

Stan Atcitty, PhD
Principle Member of Technical Staff
Energy Infrastructure and DER
Sandia National Laboratories

Phone: 505-284-2701
E-mail: satcitt@sandia.gov

