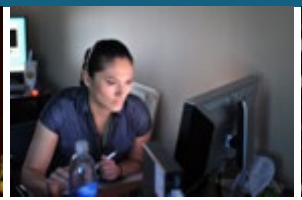
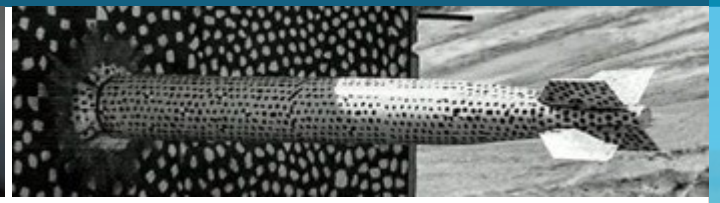
The Sandia Advanced Power Electronic Conversion Systems (APEX) Laboratory





PRESENTED BY

Jake Mueller

SAND Number: SAND2019-11279 PE

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PROJECT OVERVIEW

The Advanced Power Electronic Conversion Systems (APEX) laboratory is:

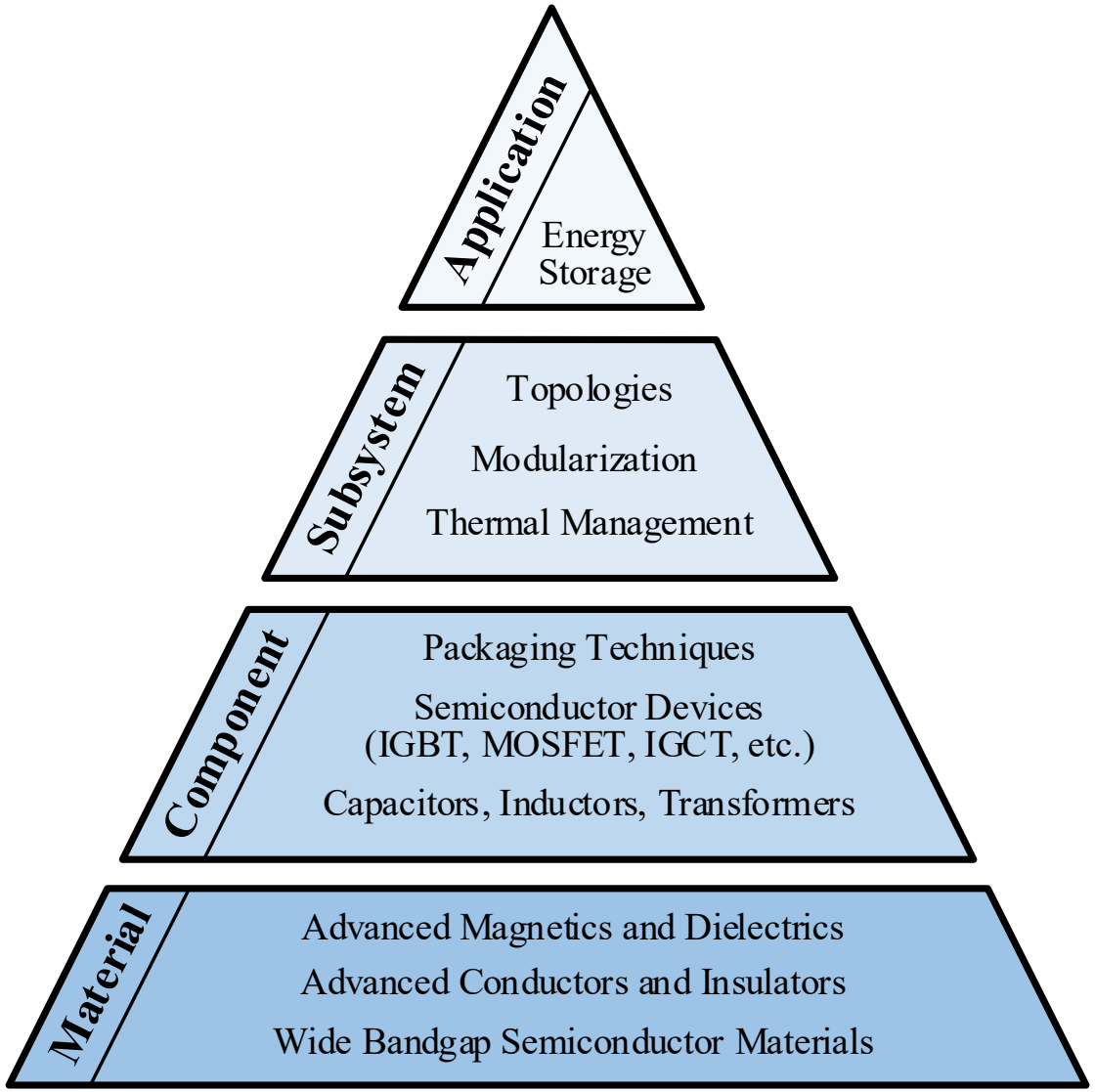
- A new facility at Sandia dedicated to the development of next-generation power conversion systems for energy storage applications
- A rapid prototyping environment for ground-up design and integration of new hardware topologies, advanced component technologies, and intelligent control systems
- The center point of a comprehensive power electronics R&D strategy

PROJECT OBJECTIVES

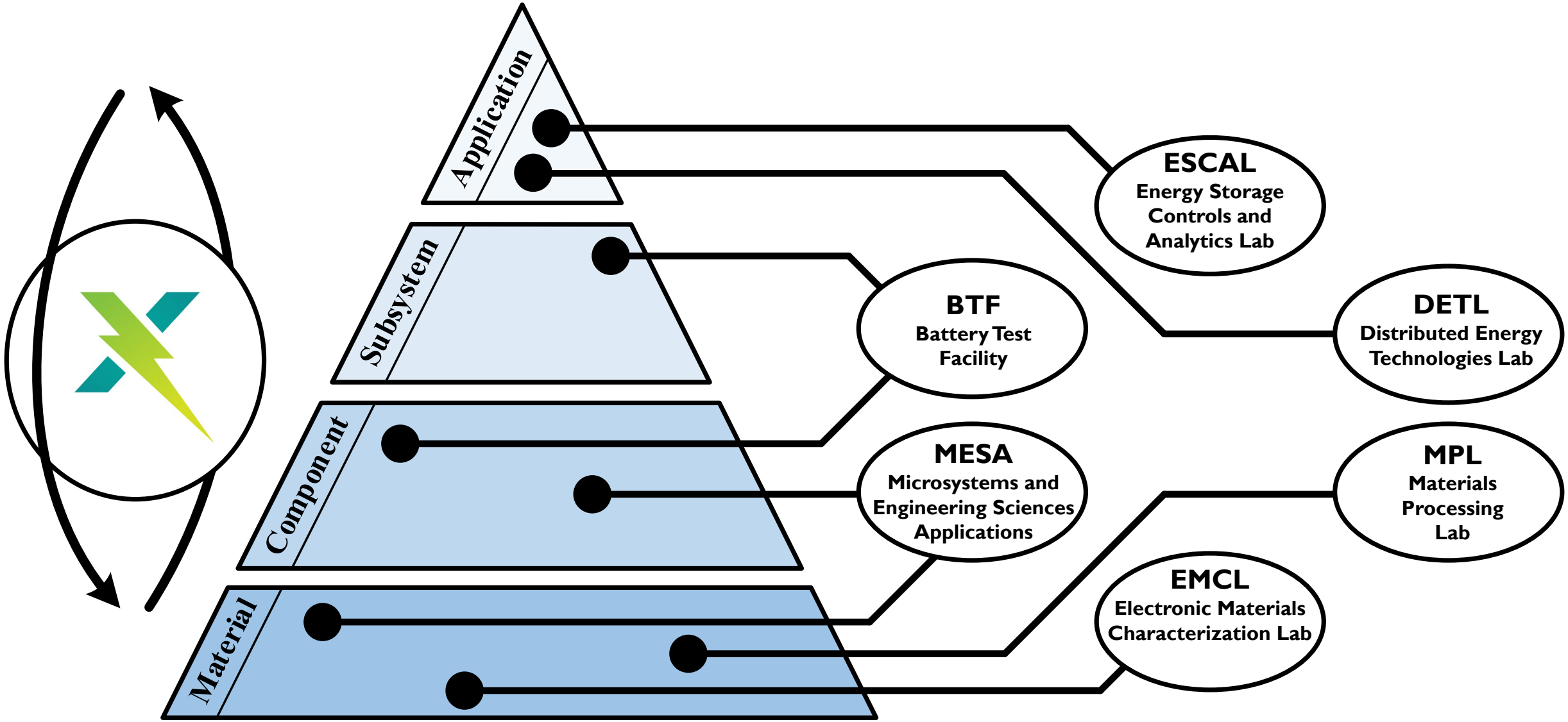
1. Identify the challenges in power electronics R&D for next-generation energy storage
   - J. Mueller, M. Moonem, S. Atcitty, and B. Chalamala "Power Conversion Systems for Grid-Scale Electrochemical Energy Storage," submitted to *IEEE Access*
   - S. Atcitty, B. Chalamala, J. Mueller, and D. Sokoloff, *Enabling Advanced Power Electronics Technologies for the Next Generation Electric Utility Grid: Workshop Summary Report*. SAND2018-9689, Sept. 2018.
   - U.S. DOE Office of Electricity Power Electronics Strategy Report (still in progress)

2. Design and implement a lab space (and research framework) to address these challenges

POWER ELECTRONICS R&D

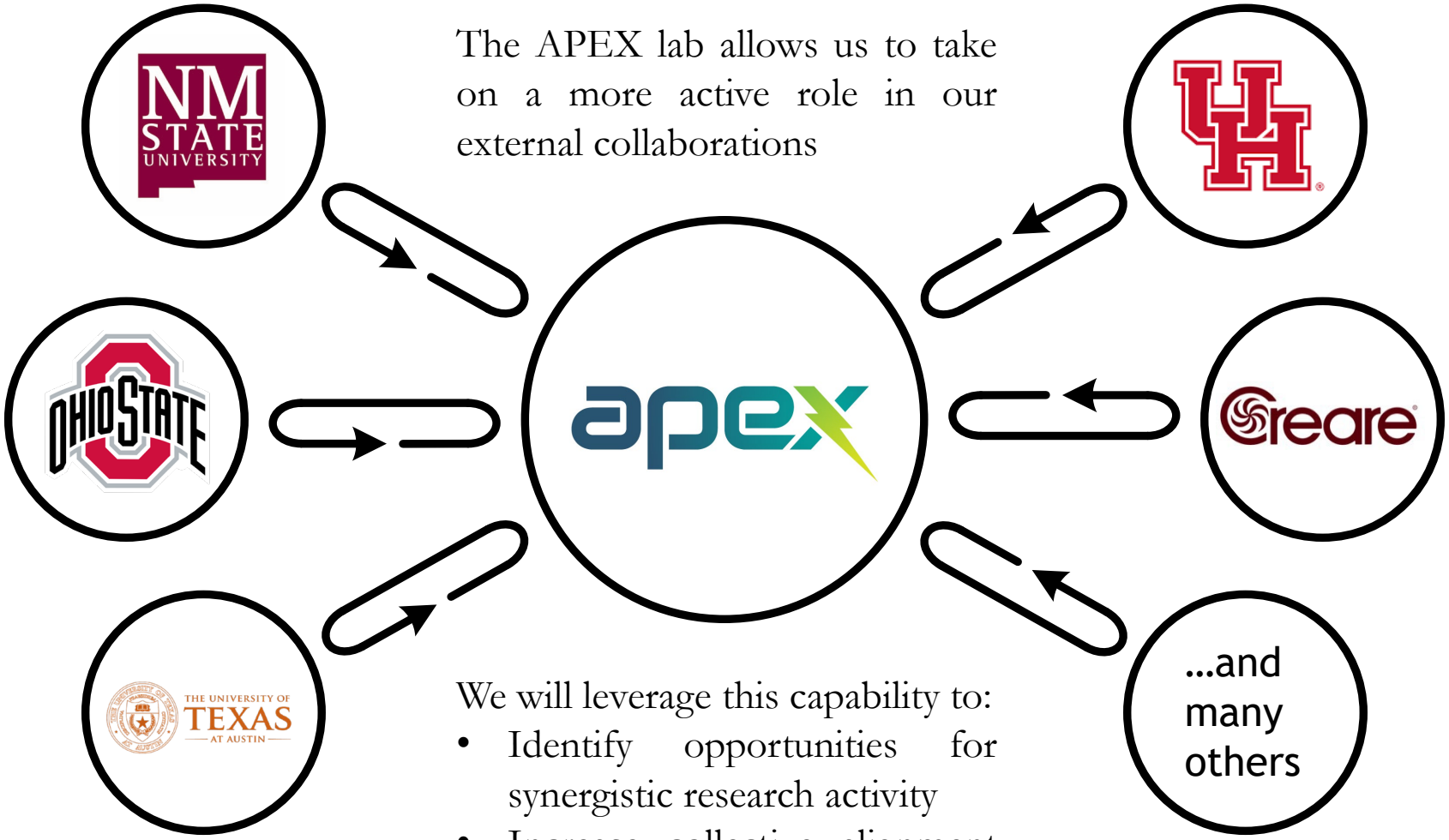


POWER ELECTRONICS R&D



STRONGER COLLABORATIONS

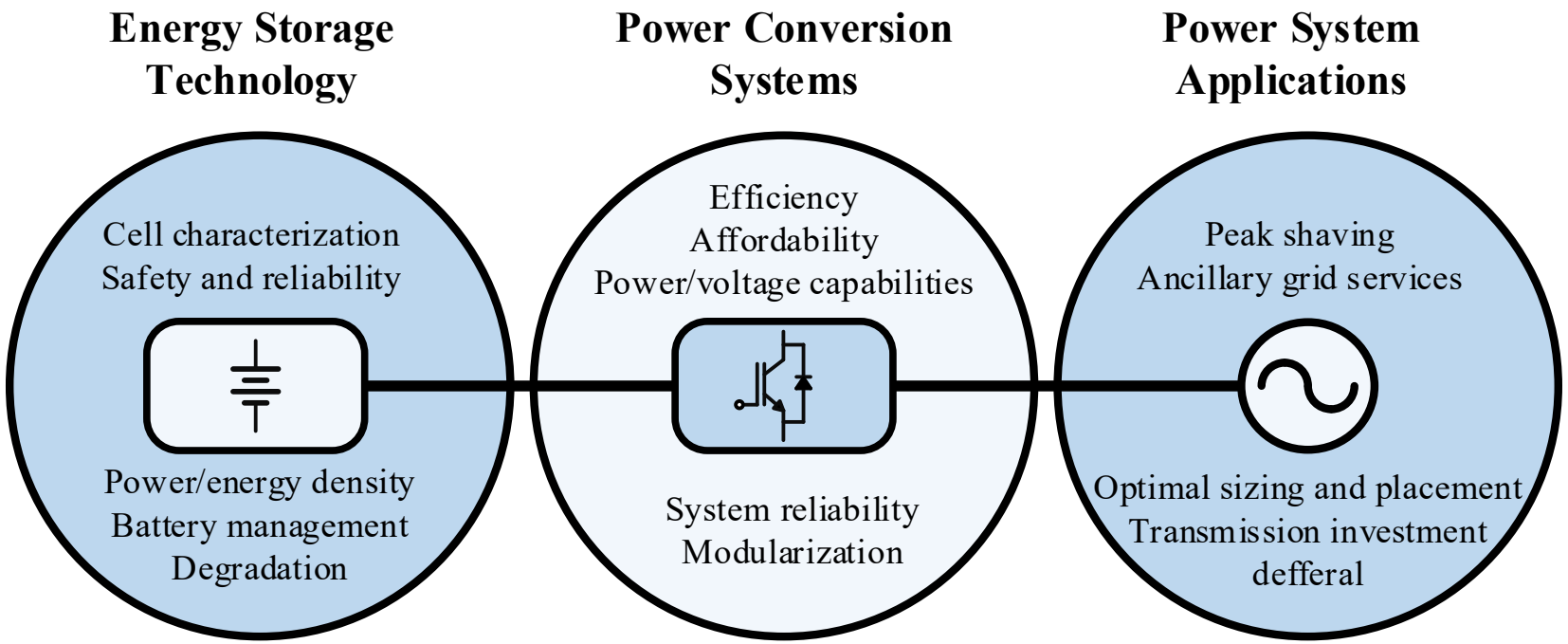
The APEX lab allows us to take on a more active role in our external collaborations



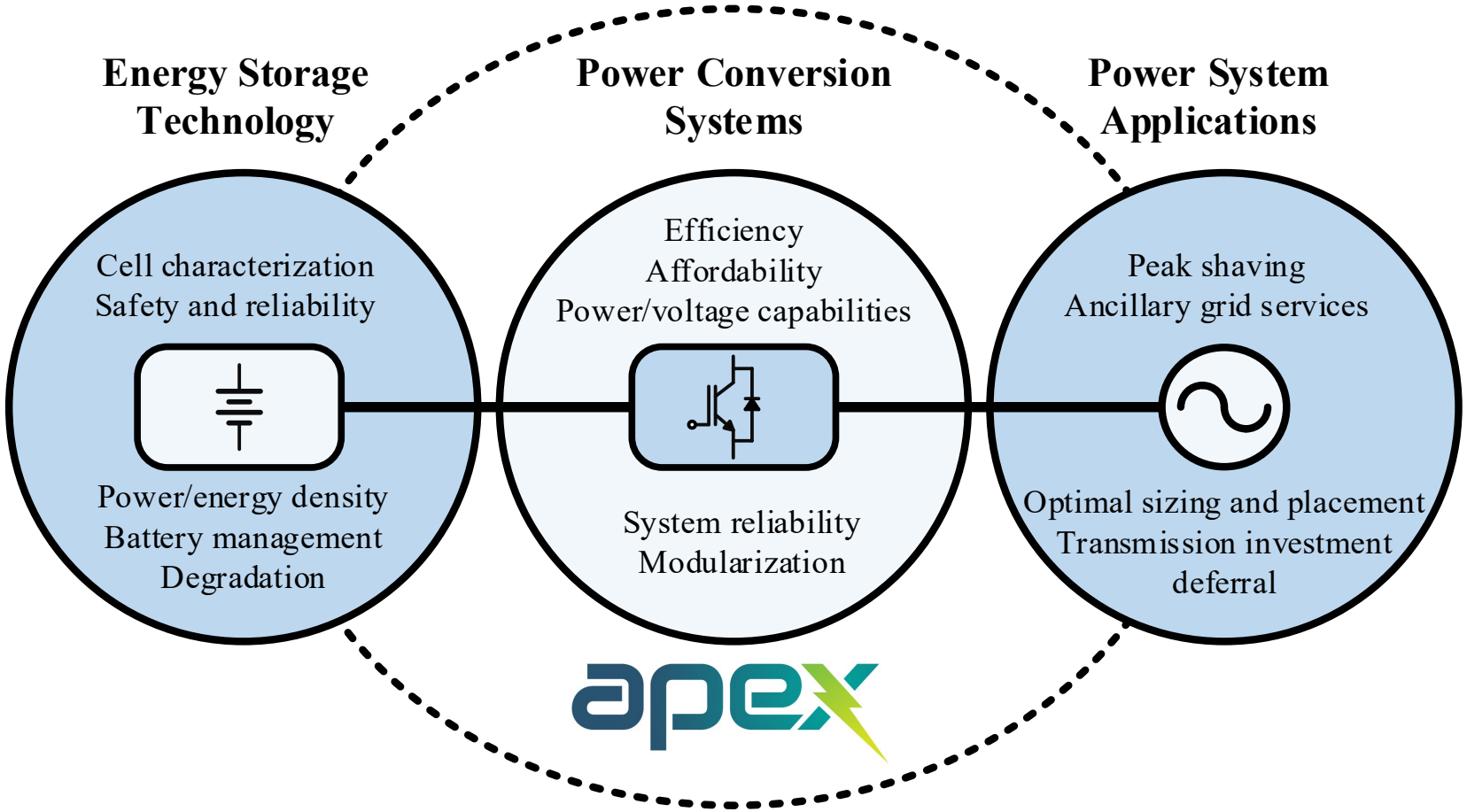
We will leverage this capability to:

- Identify opportunities for synergistic research activity
- Increase collective alignment with OE mission

ENERGY STORAGE R&D



ENERGY STORAGE R&D



APEX CAPABILITIES

Simulate Real-time simulation of components, converters, and systems
Ansys Maxwell, Matlab/Simulink, PLECS, PSIM, Opal-RT FPGAsim

Design Electrical and mechanical CAD tools for PCB design and converter assembly
Autodesk Eagle, Solidworks, Solidworks PCB, ORCAD

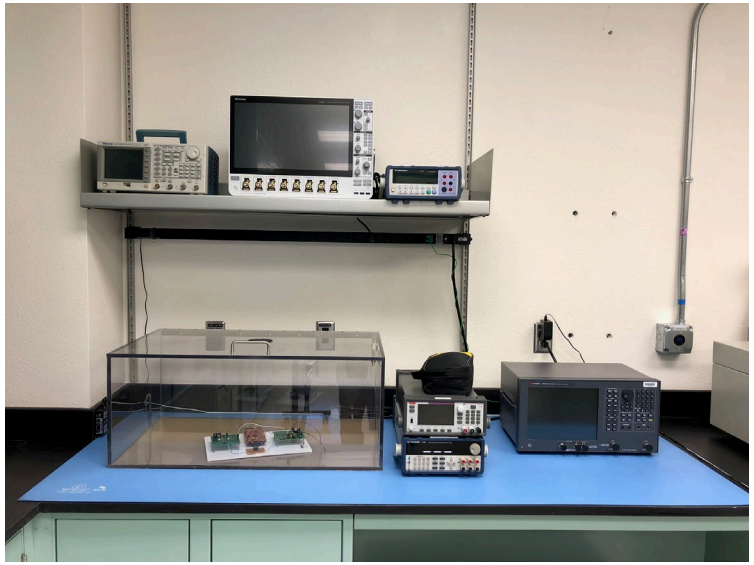
Construct Automated assembly equipment for in-house production of converter prototypes
Manncorp MC400 Pick and Place Machine, MC301 Reflow Oven

Control Reconfigurable digital control platforms for development of new control strategies
Code Composer Studio, TI C2000 DSPs, Vivado, Xilinx FPGAs and SoCs

Analyze Fully bidirectional hardware-in-the-loop testbed for assessment of converter performance in practical application scenarios
30kW Grid Simulator, DC Sources up to 950V/±40A, Comemso 144-Ch Cell Simulator

Stress Fault-tolerant source equipment and protective enclosure for destructive testing
Custom polycarbonate enclosure, Opal-RT master system controller

PROJECT OUTCOMES



LOOKING FORWARD

Target Research Areas

1. Power conversion systems for scalable energy storage deployments
   - Modular topologies for direct MV grid connection
   - Integration of storage in existing and emerging power electronic energy infrastructure
2. Uninterruptible converter topologies for critical storage assets
   - Fault-tolerant and reconfigurable hardware architectures
   - Hot-swap capable converters and storage systems
3. Applications of power electronics in storage system safety
   - Stranded energy extraction
   - Active response to thermal runaway

Expanding Lab Capabilities

- Performance analysis under extreme environmental conditions
- Additional grid simulator inputs for exploration of integrated storage in solid-state transformers

CONTACT INFORMATION

Thanks For Your Attention

We would like to thank the DOE OE Energy Storage Program and Dr. Imre Gyuk for generous financial support of this project.

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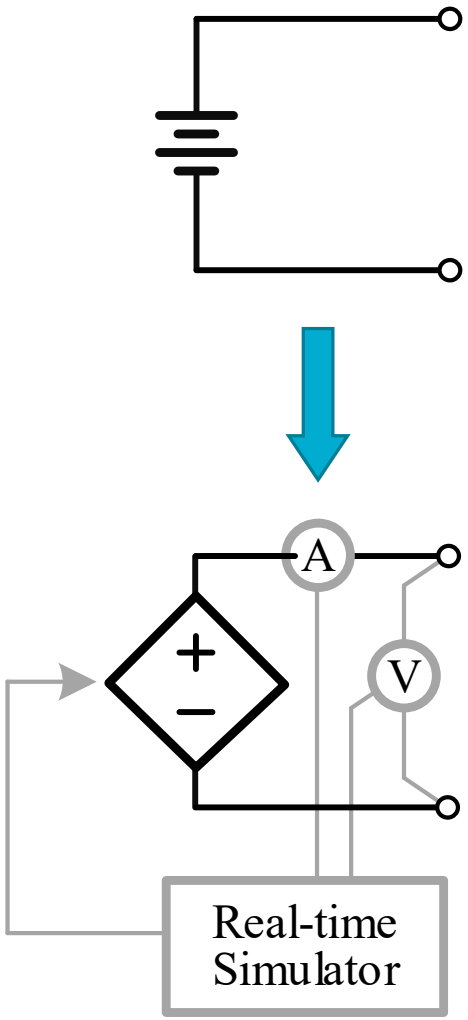
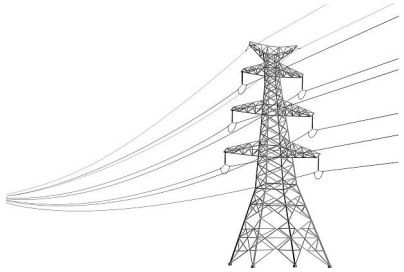
APPENDIX SLIDES

Slides with supplementary information may be found beyond this point.

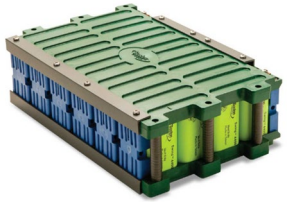
SOURCE EMULATION





Utility Grid Emulation
Chroma 61830 Grid Simulator (30kW, 480V)

System-Level Storage Emulation
Keysight RP7952A (500V, ±40A)
Keysight RP7953A (950V, ±20A)



Module-Level Storage Emulation
12x Kepco BOP 1kW (±50V, ±20A)

Cell-Level Storage Emulation
Comemso Battery Cell Simulator
144 Cell Emulator Channels (8V, ±5A)

NEXT-GEN INFRASTRUCTURE