HEAT,…, THE LAST FRONTIER

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PURPOSE

- Share lessons learned
- Stimulate discussions to catalyze inverter technology improvements
- Stimulate discussion that will support the DOE to develop new industry support programs and improve existing ones

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OVERVIEW

- Design goals
- Survey of approaches to thermal management
- Heliotronics inverter work
- Lessons learned
- Ideas for Sandia

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INDUSTRY FOCUS DU JOUR

- Get the thing to work with low harmonics and reasonable efficiency (early 80s)
- Maximize efficiency (late 80's early 90's)
- Codes and standards (mid 90's)
- Get to the bottom of the bathtub (late 90's)
- Stretch the bathtub (Now) ➔get the heat out

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HEAT SOURCES

- Power Semiconductors
  - Point sources
- Magnetics
  - Diffuse

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HEAT SENSITIVE COMPONENTS

- Electrolytic capacitors, 10C halves the lifetime
- Power semiconductors, junction should be at least 25C below rated max

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Thermal Approaches

- Exotic approaches
  - Heat Pipe
  - Convection driven liquid cooling
- Passive Extruded Heatsink on an unvented box
- Passive Extruded Heatsink on vented box
- Active cooling with vented box
- Active cooling with unvented box
- Fully passive, engineered heat sink / enclosure

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SMA
Sealed With External Extrusion

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ALPHA
Active Internal and External

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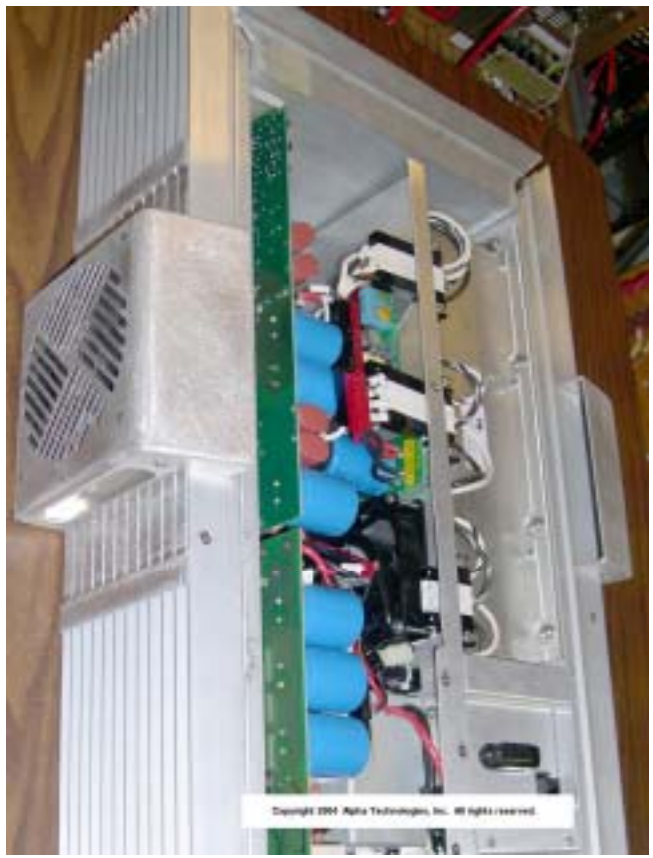
ALPHA
Active Internal and External



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OUTBACK
Sealed With Active Internal

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OUTBACK
Vented Active Internal

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OUTBACK

Sealed, Active Internal and External

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ADVANTAGES OF CAST AL

- Large distributed surface area
- Engineered control of heat flow
- Relatively easy thermal partitioning
- Fully passive
- Can be sealed
- Can pot the magnetics
- Solid modeling and thermal design tools easily integrated into the design process

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HELIOTRONICS EXPERIENCE

- Funded through 3 NYSERDA awards
- High reliability and serviceability emphasized
- Heavy emphasis on effective passive cooling design
- Cast AL enclosure / heat sink

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TESTING SUPPORT FROM SANDIA NATIONAL LABORATORIES

- Thermal
  - Chambers, Imaging and TC
- Anti-Islanding Performance Confirmation
- Surge Testing
- MPPT
- Power Quality, THD and Power Factor
- Conducted RFI

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THERMAL "BAG OF TRICKS"

- Potted magnetics move heat to the exterior without vents
- Large surface area allows fully passive cooling
- 3D geometry provides flexibility:
  - Fin design
  - Component mounting
  - Partitioning
  - Engineered heat flow

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THERMAL DESIGN PROCESS

- Concept
- Model
- Modify
- Build and Test

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CONCEPT

- No fins
- Distribute heat by varying wall thickness
- Pot magnetics
- Strategic semiconductor mounting
- Enclosure partitioning

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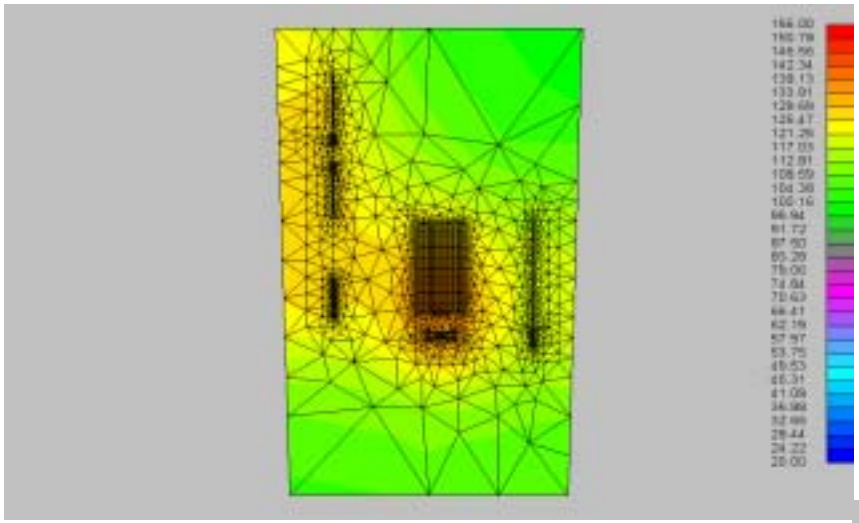
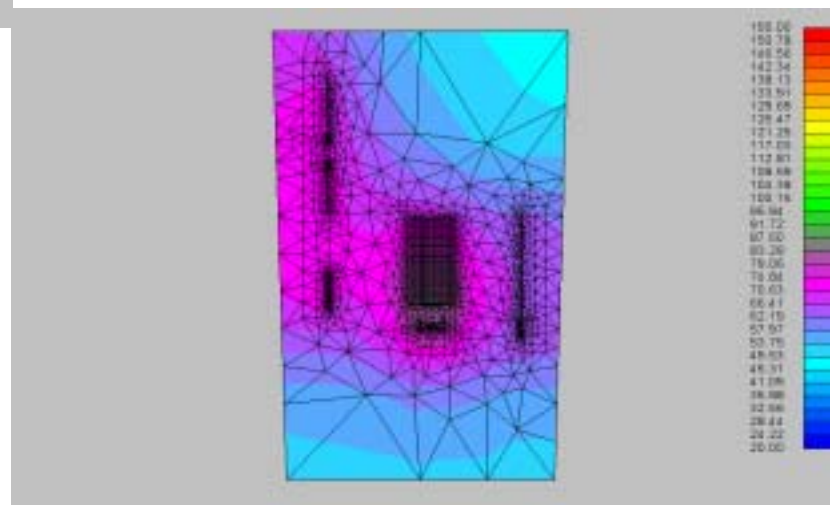
SIMULATION SHOWS FINS ARE IMPORTANT



Fins reduced junction temperature by 50C

Add fins to the design.



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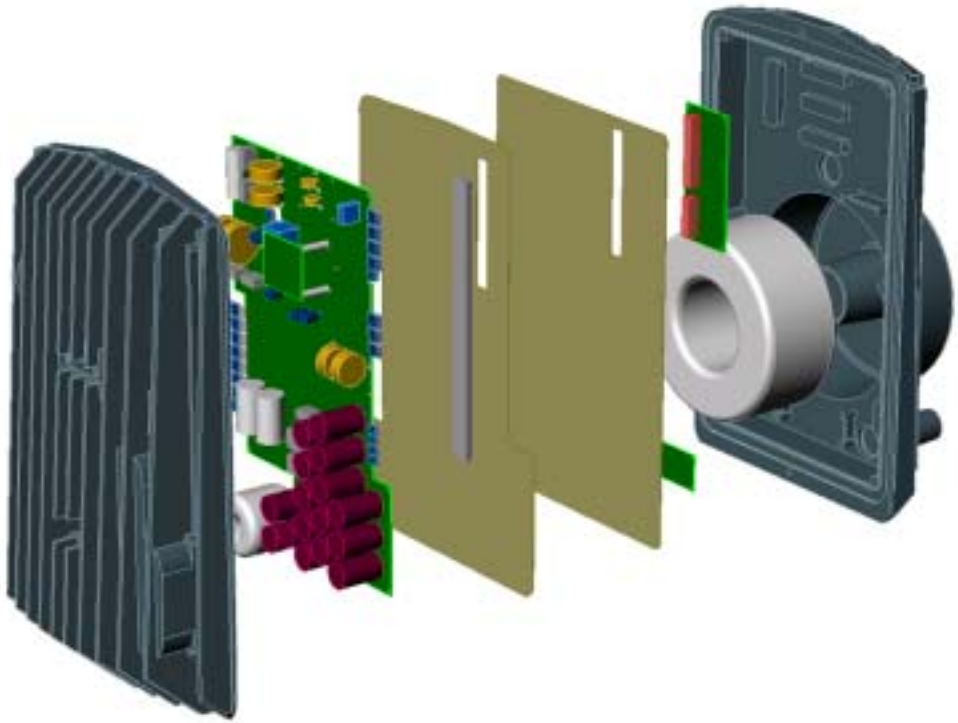
ADD FINS AND FINALIZE



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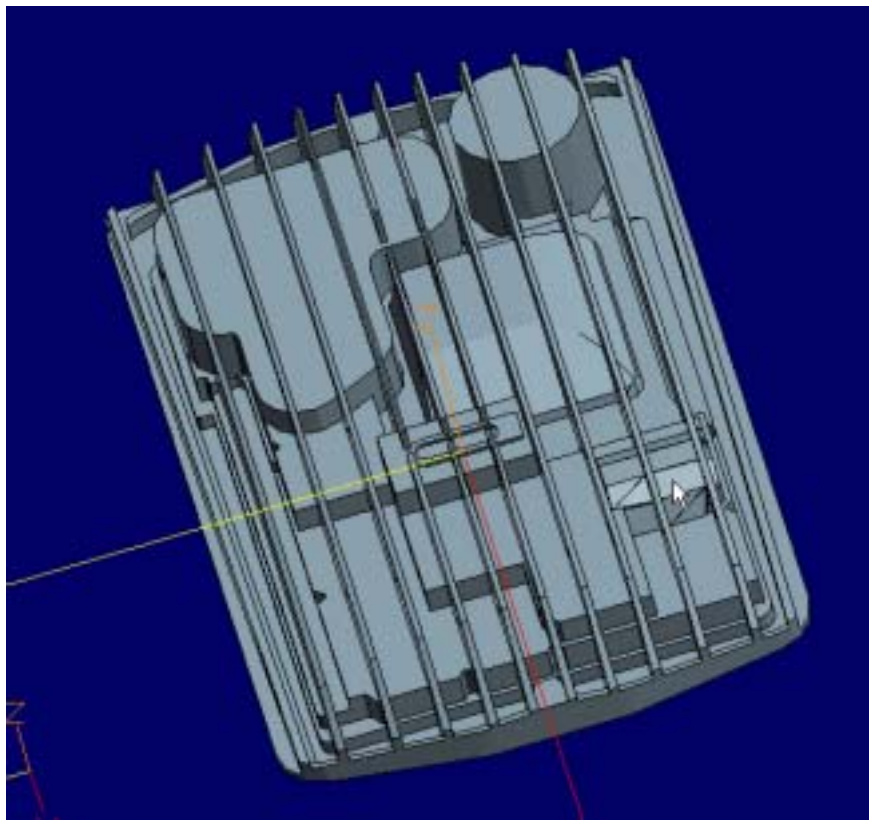
SOLID MODEL SHOWING EXTERIOR CONTOURS



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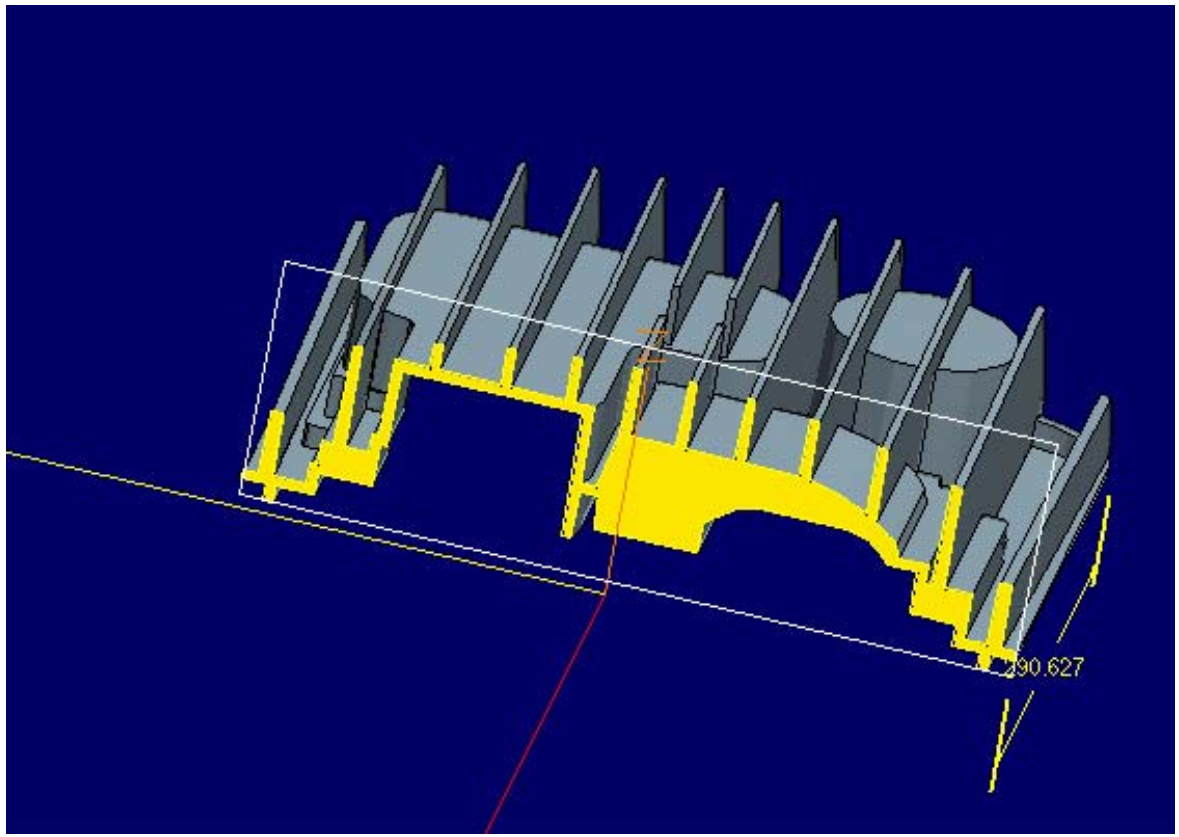
ENGINEERED HEAT FLOW



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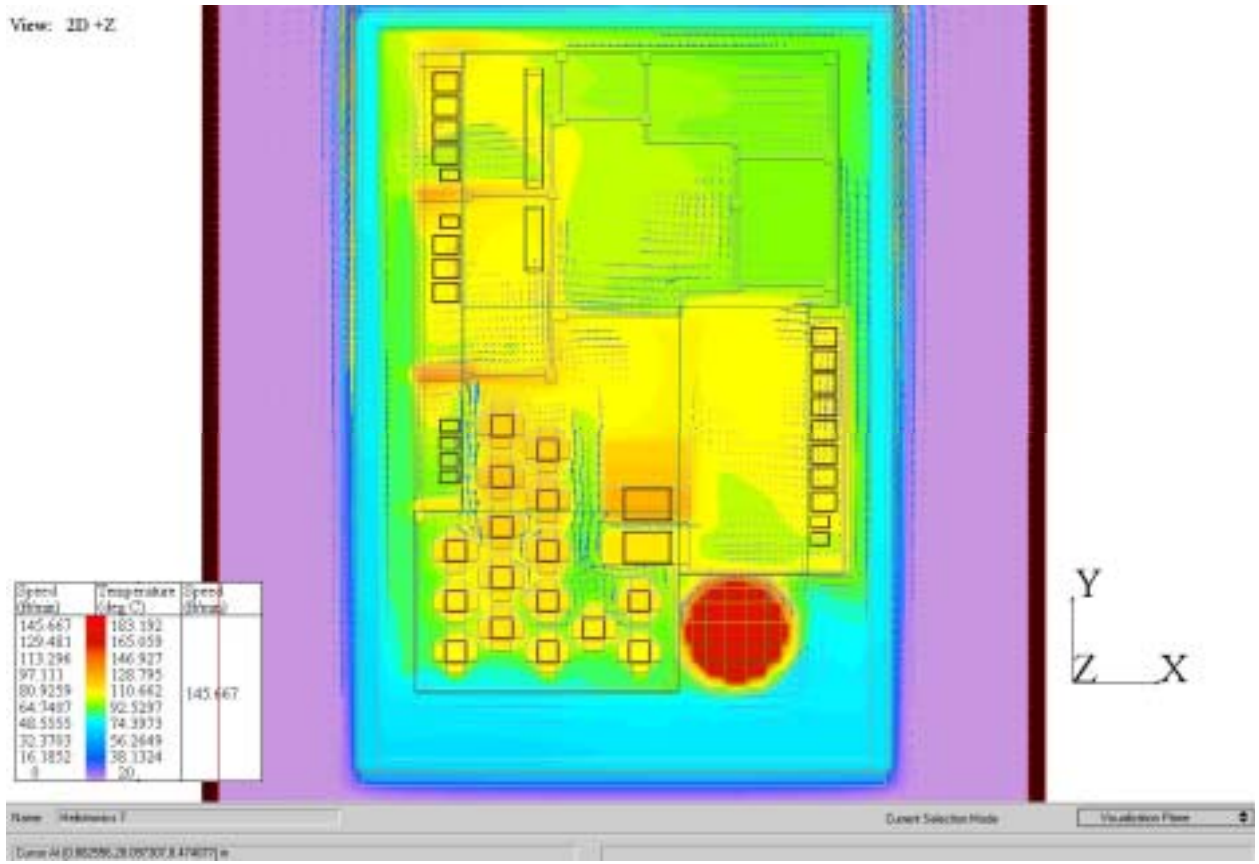
MODEL LAYOUT



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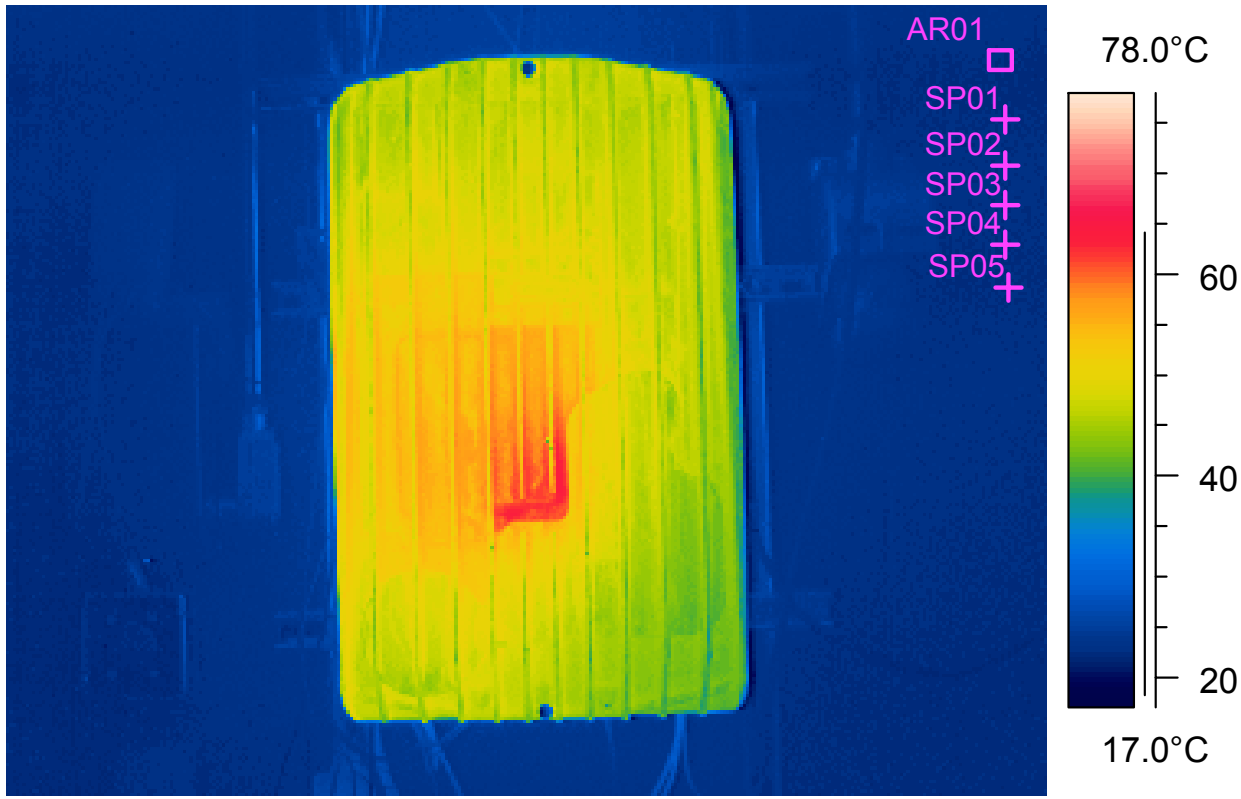
BUILD AND TEST

Image by Sandia National Laboratories



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UNIT IN THE FIELD

High IR Emissivity Paint

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LESSONS LEARNED

- Very helpful having thermal design as part of the process from the beginning
- Cast AL is very promising as an approach to long lifetime high reliability inverters.
  - Heliotronics results
  - Outback Power's successful commercialization of cast AL enclosure
- Thermal modeling is a valuable addition to the designers tool box

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THOUGHTS FOR DOE

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SANDIA'S FUNDING ROLE

- Great engineering still coming out of small companies, should diversify project portfolio between low risk and high risk players. Must fund the innovators who have limited access to capital.
- Large players should be encouraged to commercialize through acquisition if technology is proven. E.g. Beacon Power purchase of Advanced Energy technology. The technology doesn't die even if the organization does.

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SANDIA'S EXISTING SERVICE ROLE

- Continue high capital testing services:
  - Environmental chambers
  - IR Imaging
  - HALT
  - Surge testing
  - MPPT on solar array
- Speed turn around
- Upgrade equipment where needed (IR Imaging)

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POTENTIAL EXPANSION AREAS

- High end 3-d thermal modeling compatible with industry standard tools such as Solid Works
- Component testing and verification, for example, EL capacitors, power semiconductors, connectors, fans. Well designed booklets covering these technologies would be extremely beneficial.
- Be a catalyst in system standardization, for example: Inverter connectors, data communications.

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