

# PROGRESS ON A 100kW LOW COST ENERGY STORAGE INVERTER

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Technical support and management provided by Sandia Labs



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# ACKNOWLEDGMENTS

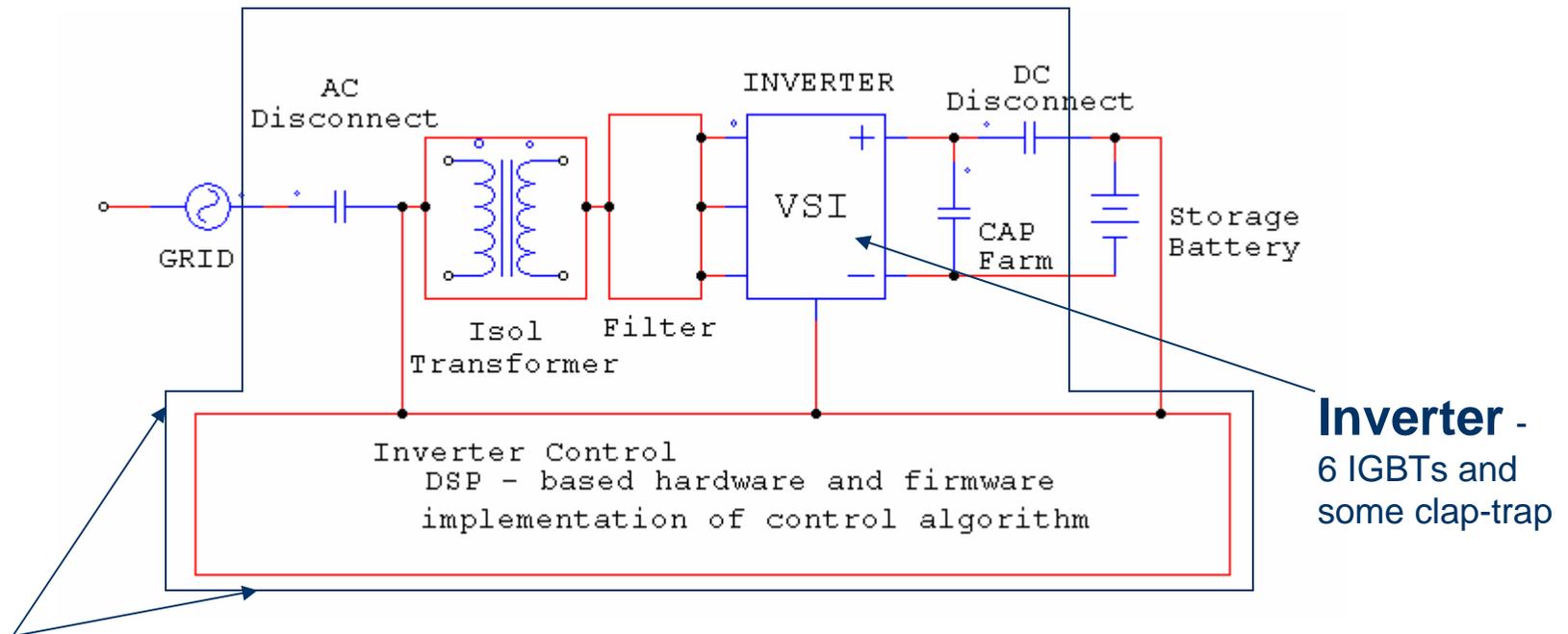
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- ◆ **Funded by the Small Business Innovation Research (SBIR) program of the U.S. Department of Energy (DOE/ESS) and managed by Sandia National Laboratories (SNL).**



# Storage System Block Diagram

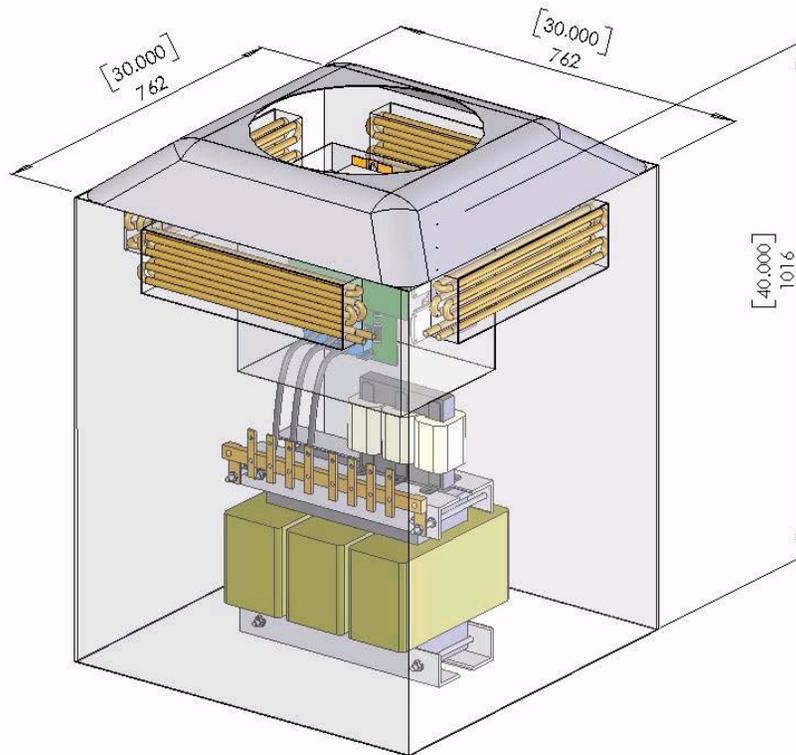
Let's agree on some terms... Inverter vs PCS



**PCS** - the entire system



# PCS Assembly - Concept meets Reality



The inverter measures 28 x 28 x 36 in and 760lbs:

0.216 kVA/L

0.29 kVA/kg



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## Full PCS System in a box - not just an inverter

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- system level circuit protection devices (including AC and DC disconnects, fast fault-limiting fuses, circuit breakers, etc.);
- line-frequency isolation transformer (660 lbs of our total, and the single largest cost item in the system!);
- closed fluid cooling loop, including power module heat exchanger, flow and temperature monitoring, and cooling radiators;
- graphical user interface and monitor, including local PC-based and Internet WAN-based communications;
- control power and housekeeping functions.



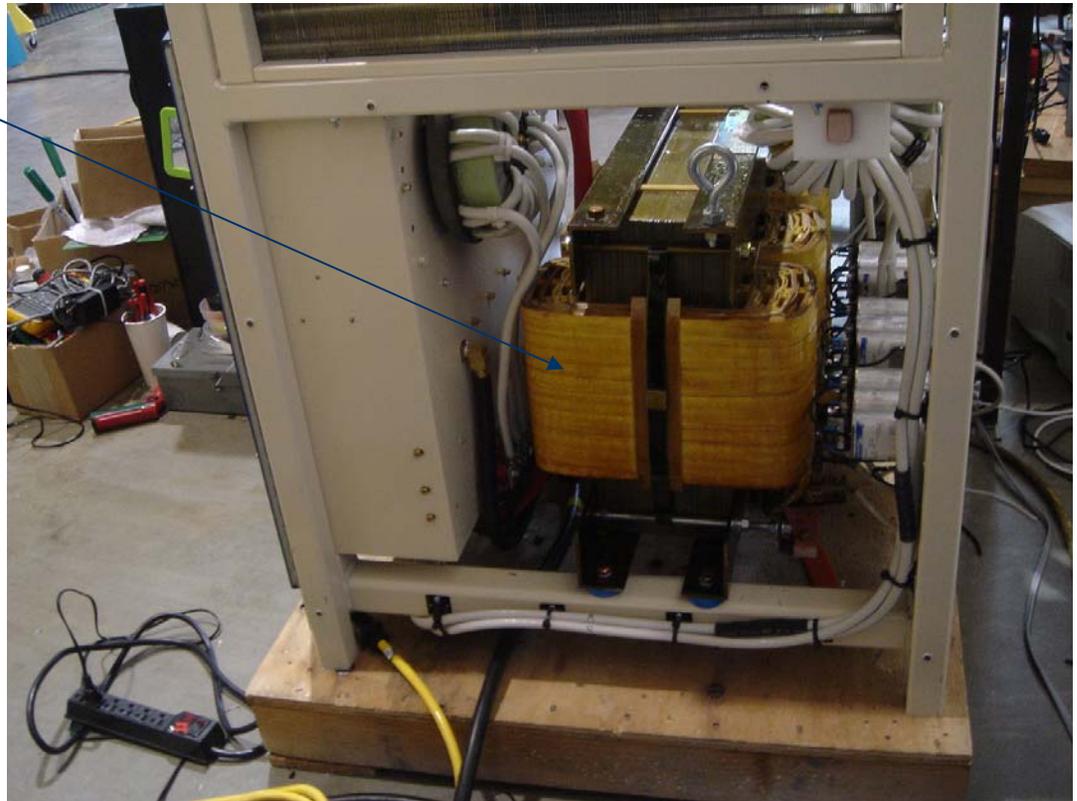
# Line Frequency Isolation

The line-frequency isolation transformer takes up 30% of the volume, 80% of the weight, and is the single biggest cost item in the system

Hi-frequency isolation would save over 500lbs and reduce volume significantly, but at a large additional cost

- estimated ~ \$50/kVA adder

We need to follow the PV industry and get non-isolated systems approved to allow reasonable cost storage systems



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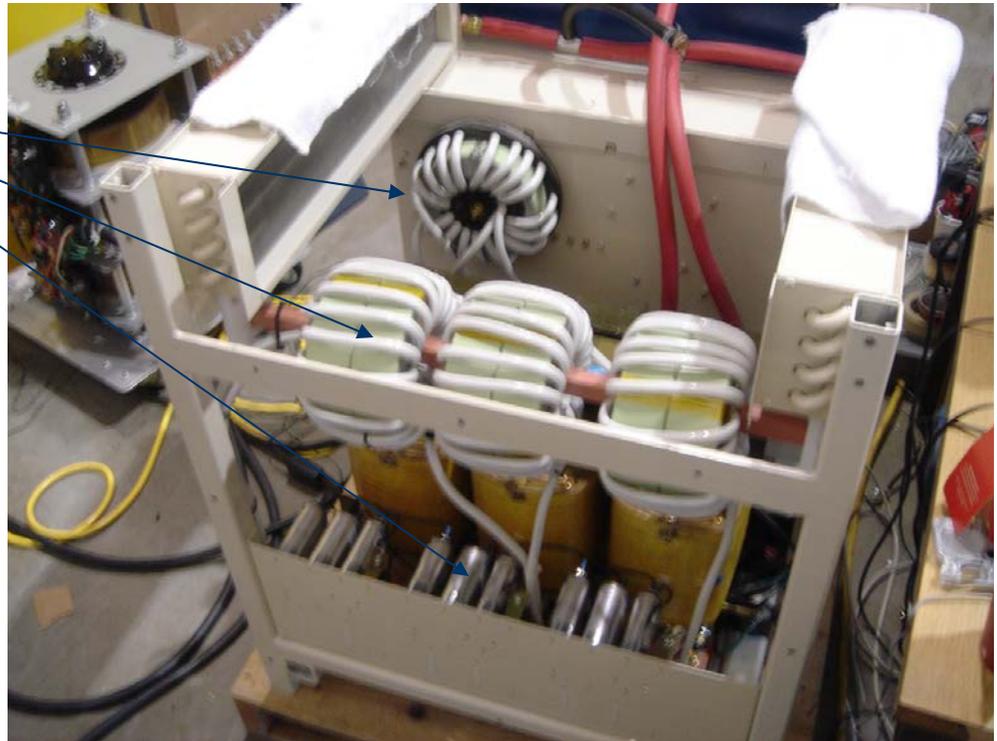
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# EMI Suppression

EMI Filtering for IEC and FCC interference suppression and susceptibility compliance is a major cost item, a major volume item, and a major efficiency item

There IS no easy solution to this problem...

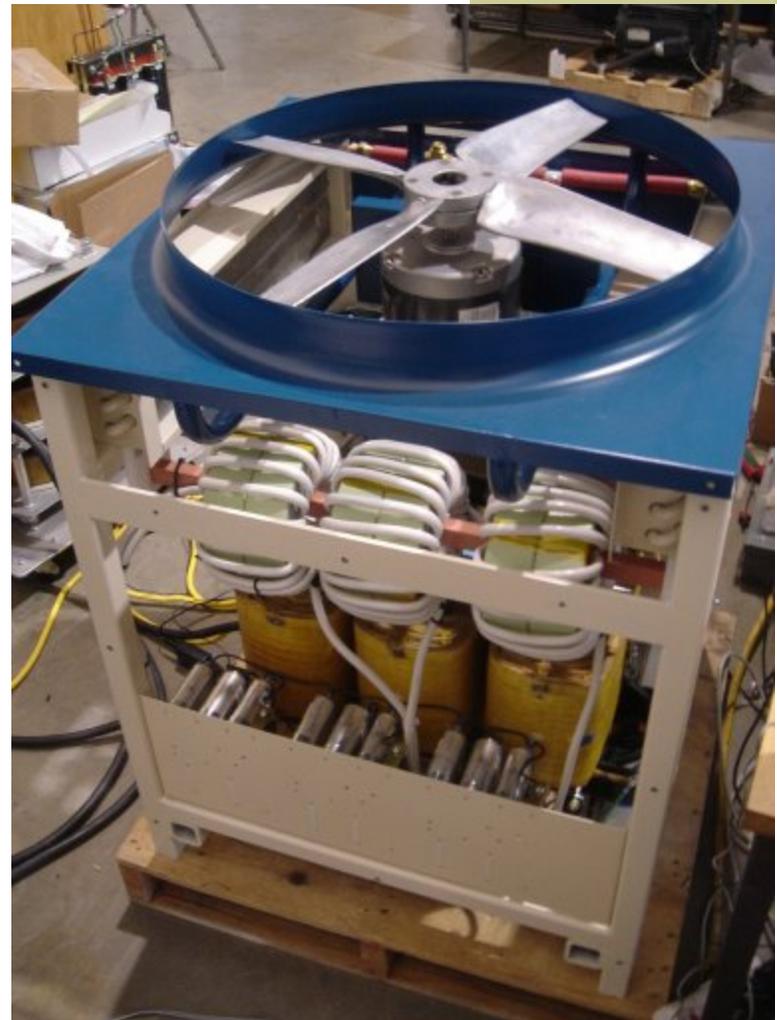


# Cooling

It turns out the major cooling challenge is not the closed loop fluid cooling system

- a 200cfm muffin fan would suffice in a 50oC ambient

The real challenge is air handling, getting sufficient air through the transformer and EMI suppression magnetics, and avoiding heat conduction into the sealed controls cabinet

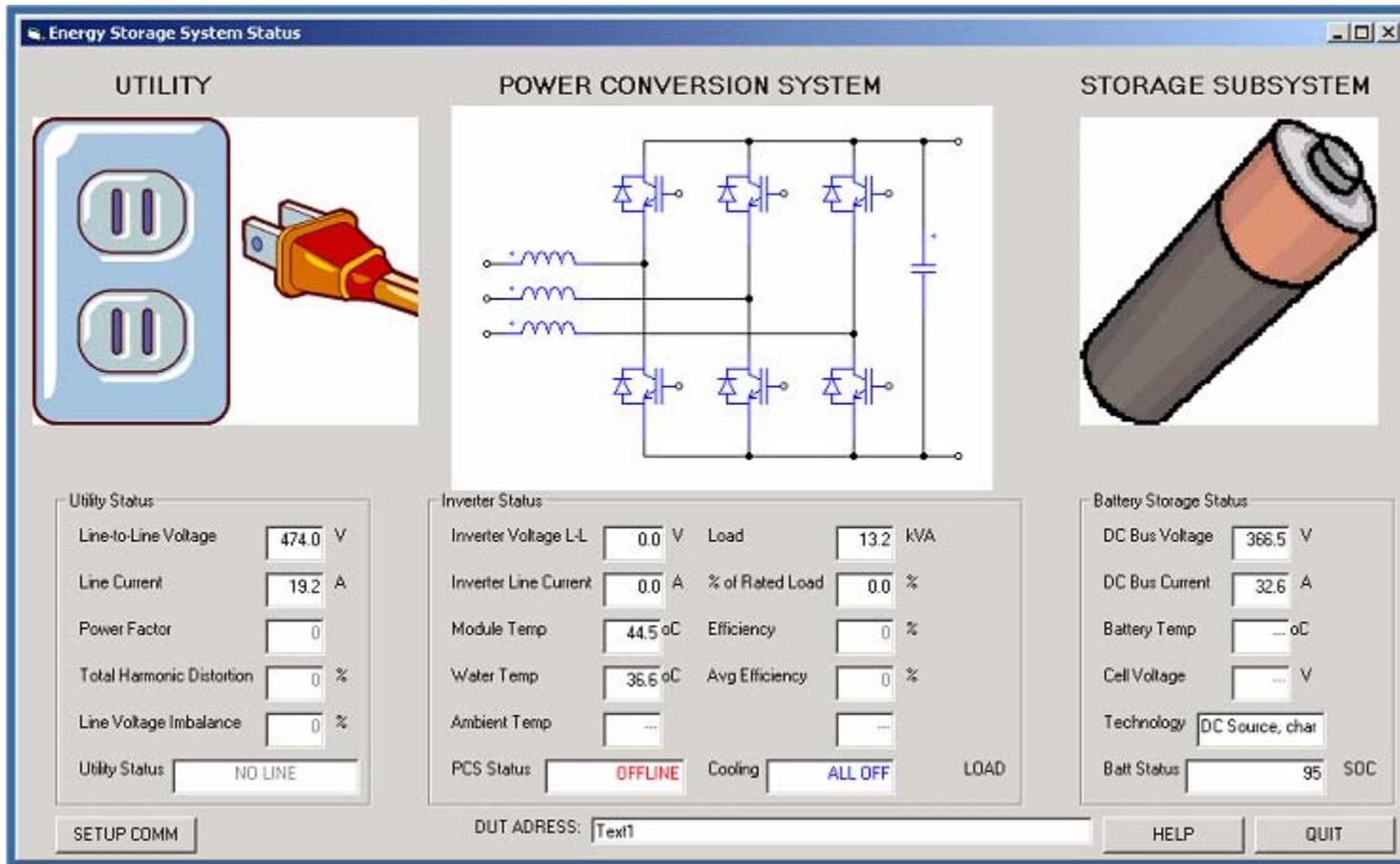


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# Operator Interface and Communications



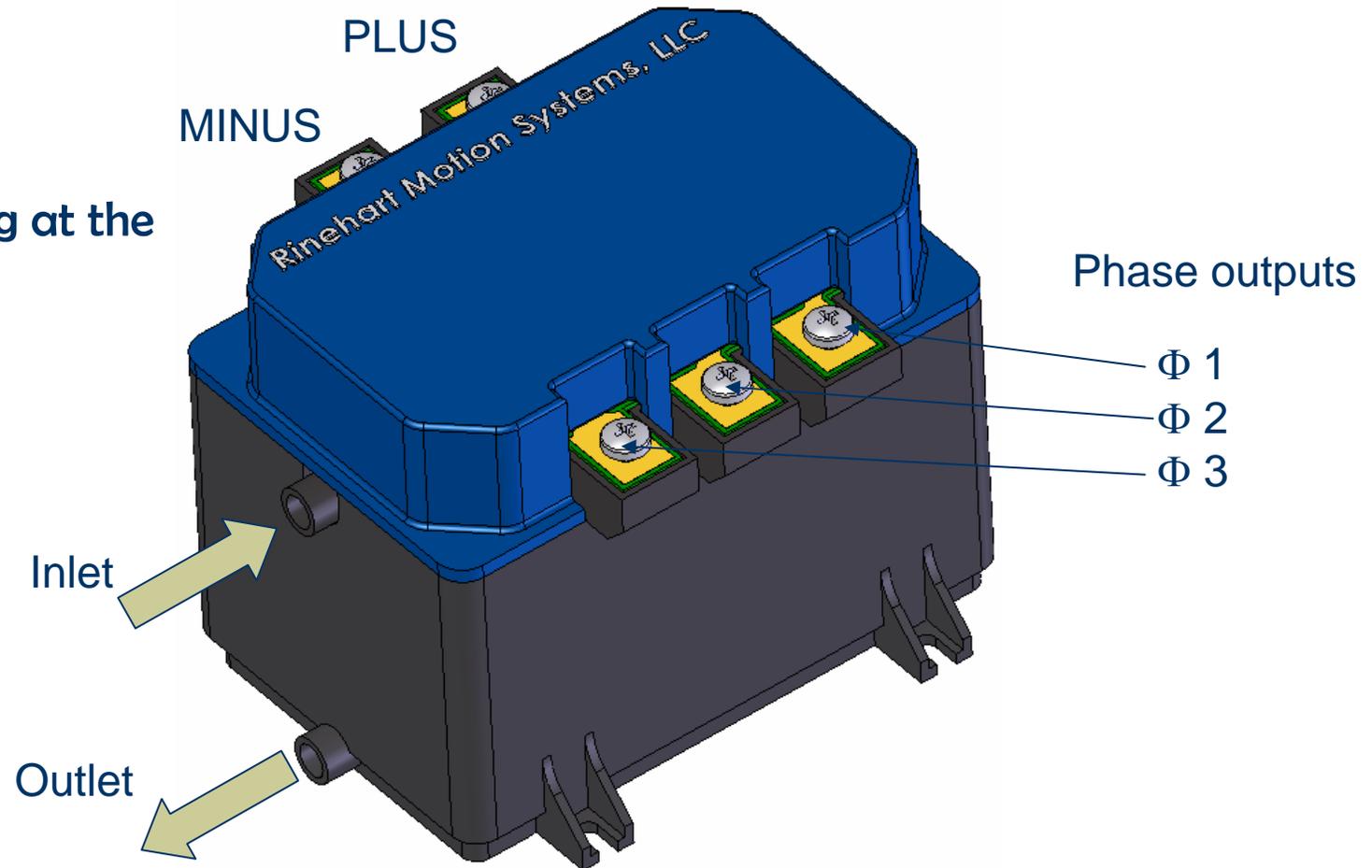
# Where do we Go from Here?

- ◆ Production prices are estimated at \$120/kVA with this system at 100kVA - 60% of market price, but still too high
- ◆ Currently, only LA batteries are supported. We need to add algorithms for Ultra-Capacitors, and other more reasonable battery technologies
- ◆ Develop a non-isolated PCS strategy
- ◆ Target a niche market to adopt the technology
- ◆ Fabricate newer, better, small and large PCS systems based on new Inverter hardware...



# 30kW non-Isolated Inverter Concept

We're starting at the small end...



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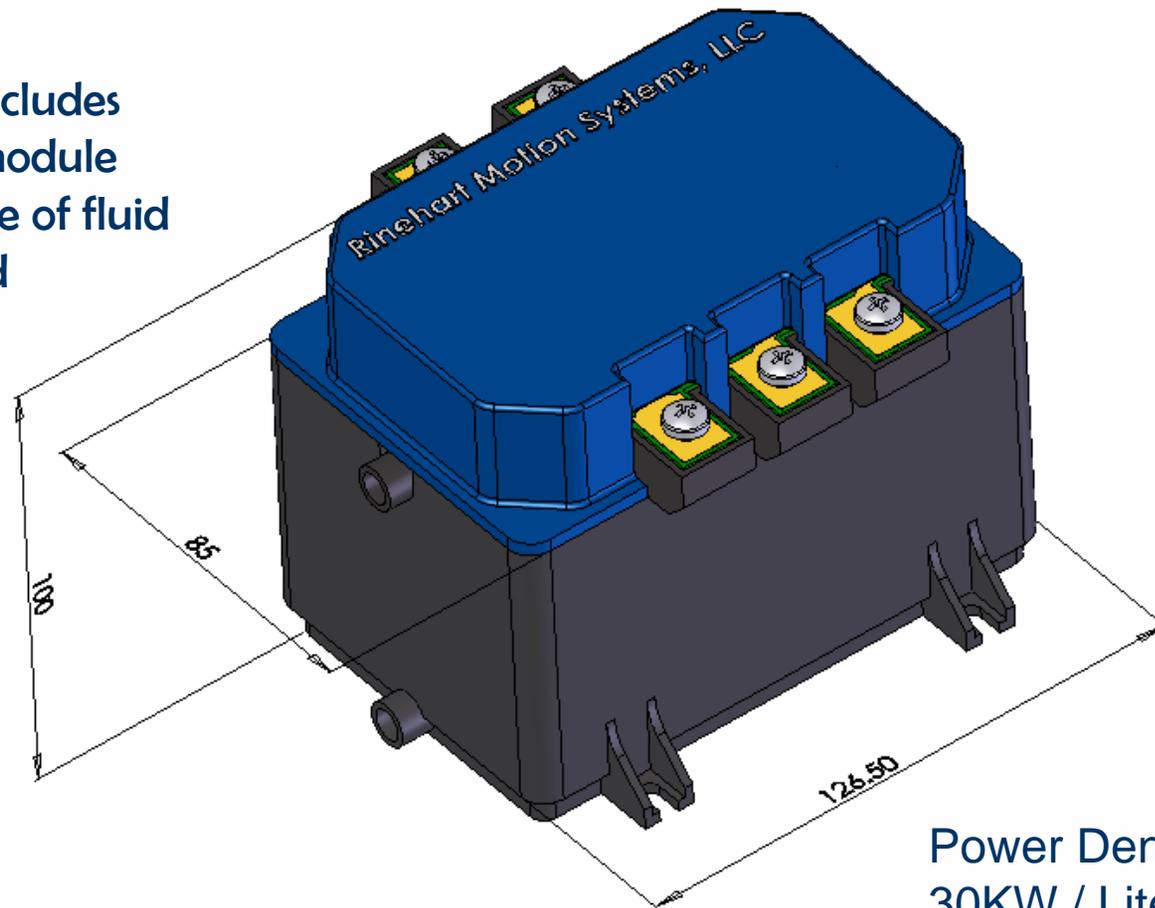
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# Estimated Size of the new Inverter

**OVERALL DIMENSIONS: 85mm x 100mm x 126.5 mm = 1.07 liters**

With a new concept that includes the Bus Capacitors in the module package, taking advantage of fluid cooling to decrease size and increase life



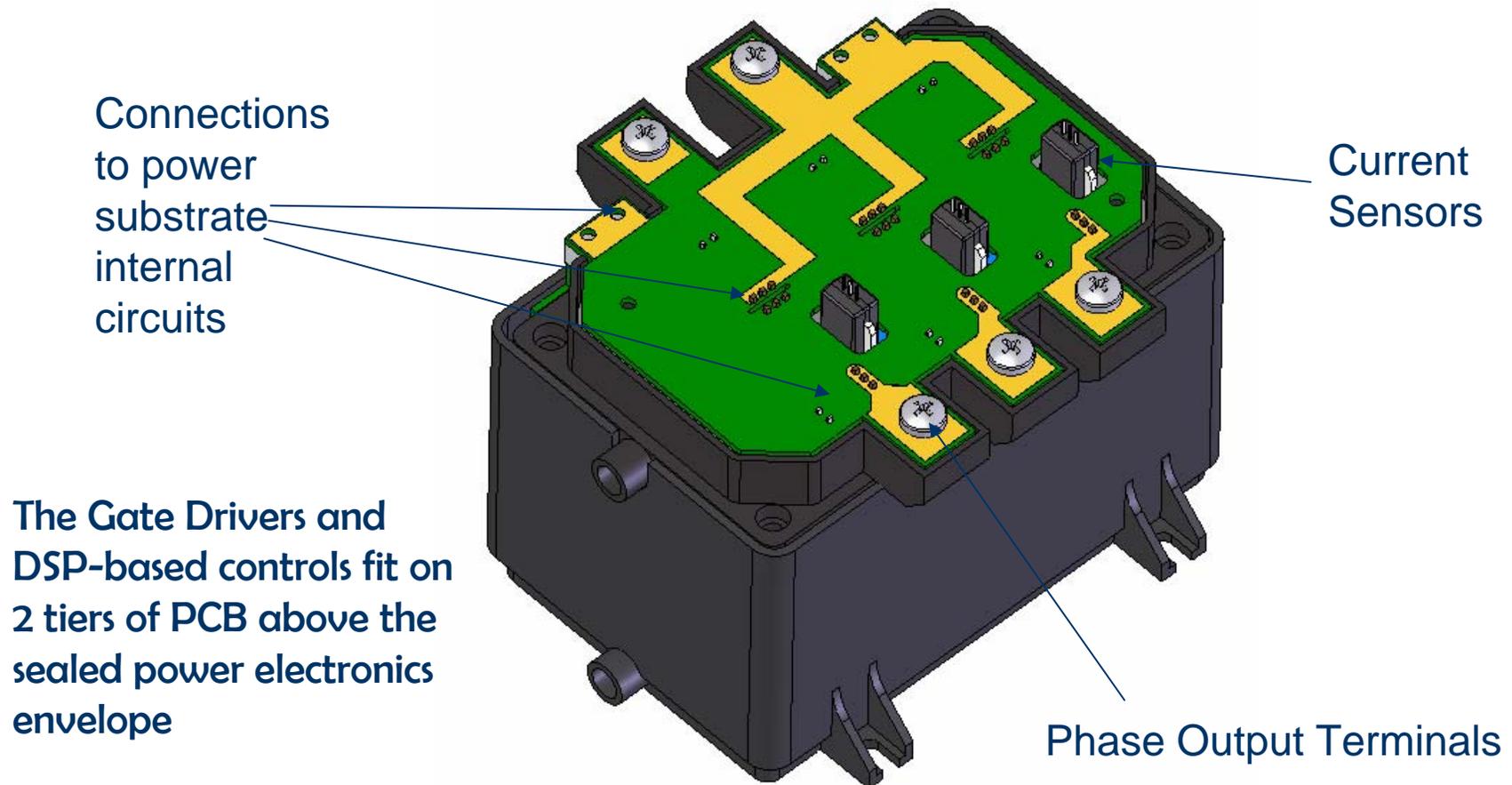
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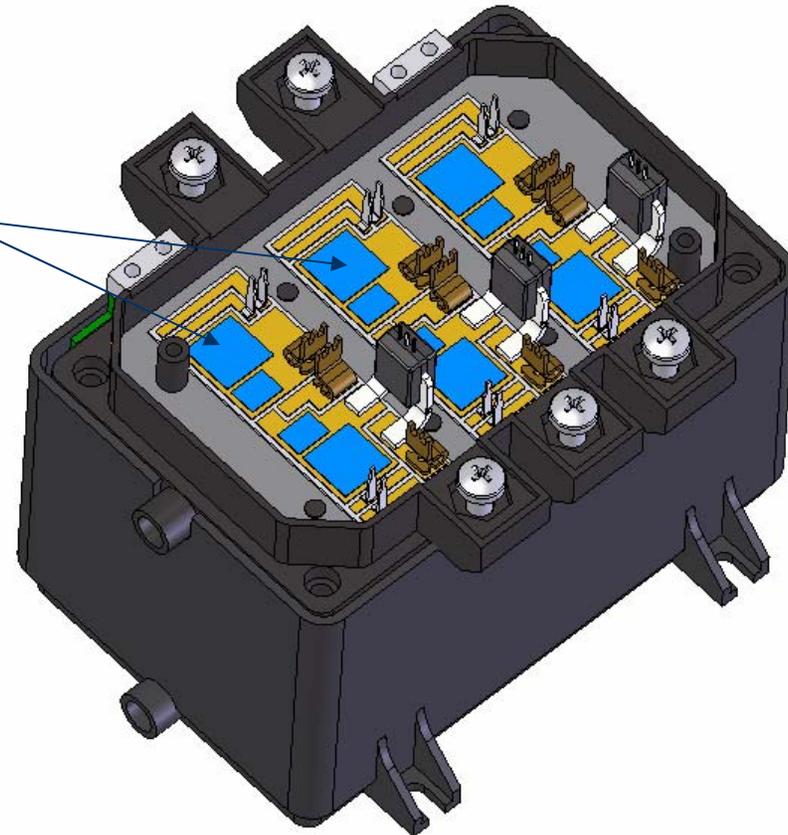
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# Internal Control Electronics

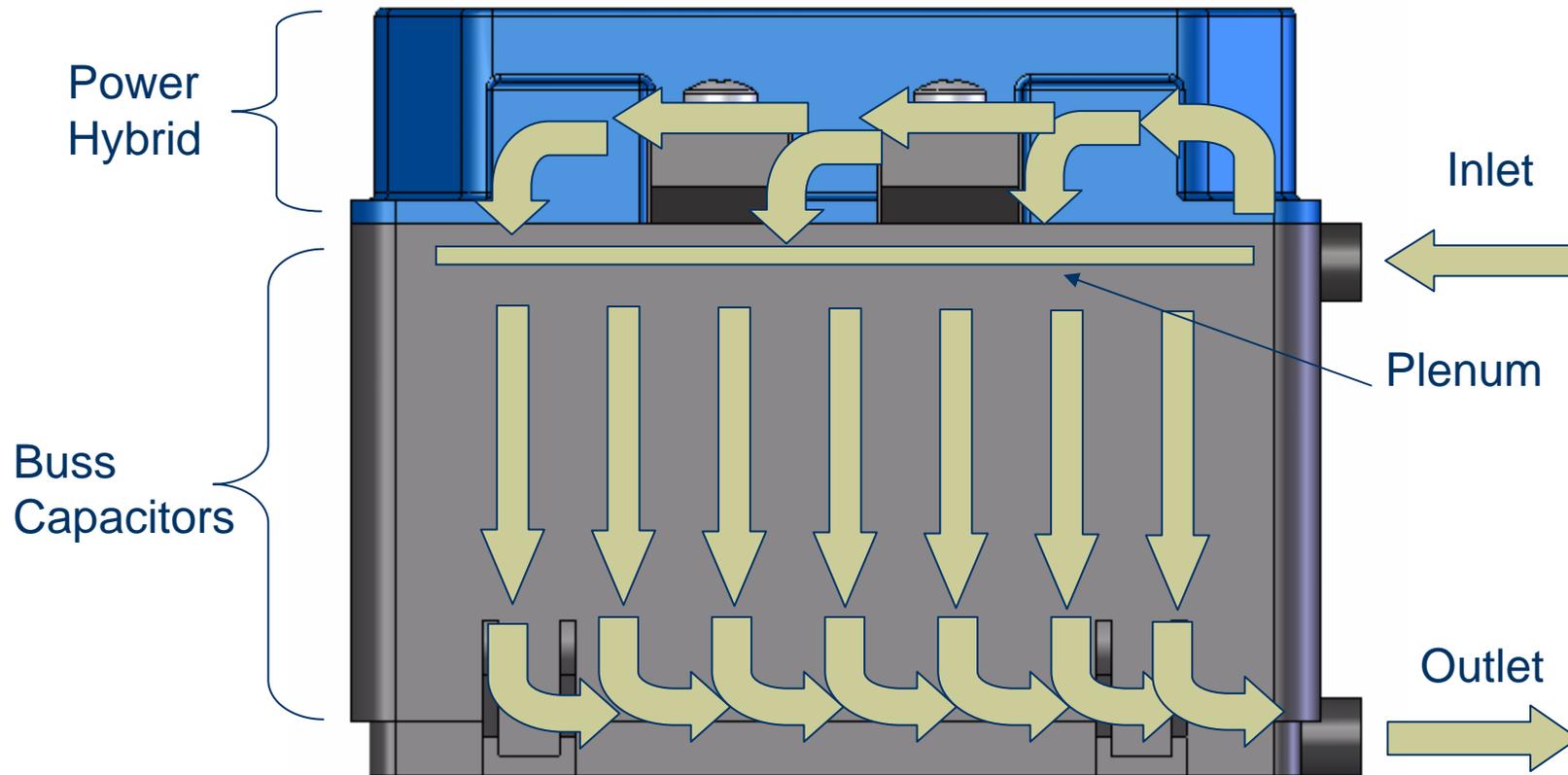


# Power Semiconductor Assembly

IGBTs and Diodes mount internally on small substrates that are cooled by the fluid flow



# Cooling Fluid Flow Field



# Summary

The INVERTER is the easy part - the Power Conversion System for an Energy Storage application is considerably more complex...

There is still considerable room to reduce costs for Inverter hardware, and especially for the PCS System

- But, doing so requires some significant changes to regulatory guides and to industry practice

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