

Green Revolution Cooling

The CarnotJet™ System: Liquid Submersion Server Cooling



This is one of the most powerful and efficient server cooling systems in the world. It has over 100 kW of cooling potential per rack and can reduce a data center's total energy use by 50%. It accepts any OEM server and can reduce total data center build-out cost by up to 40%.



Four-Rack CarnotJet™ System Installation



Liquid Submersion Cooling



Why

- Reduce data center cooling energy use by 95%
- Reduce server power consumption by 10-20%
- Use **any** OEM rack-mounted server, CPU, or GPU
- Potential to support high densities of 100kW+ per rack
- Lower upfront cost to build a data center

How

- GreenDEF™ liquid coolant holds 1,200 times more heat by volume than air
- Total server submersion allows for maximum heat dissipation
- No need for CRACs, CRAHs, chillers, or fans

Who

- Customers include three of the Top 500 supercomputing sites in the U.S. and Europe, a major U.S. bank, and more

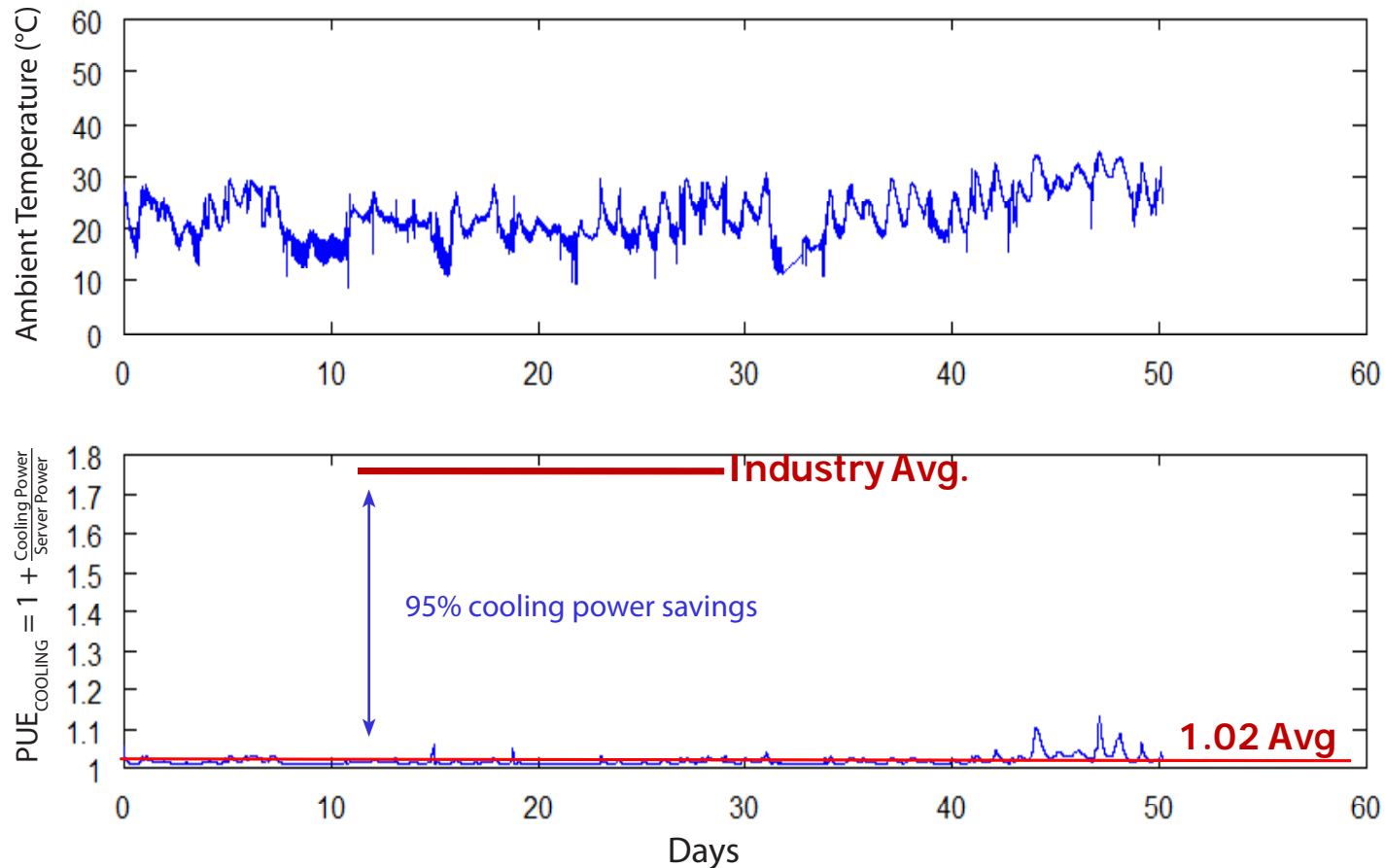
What is dielectric liquid submersion cooling?

Liquid submersion cooling has been the standard for many industrial high density cooling needs since the 1920s. Many high voltage electrical transformers, circuit breakers, capacitors and power substations depend on liquid cooling.

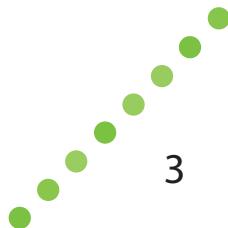
Our complete server cooling systems for data centers feature GreenDEF™ coolant, a non-conductive liquid similar to white oil. Our coolant is chemically stable, clear and odorless, low priced, non-toxic, and environmentally friendly.



Proven Energy Savings



* Additional 10-20% reduction of server power with removal of server fans

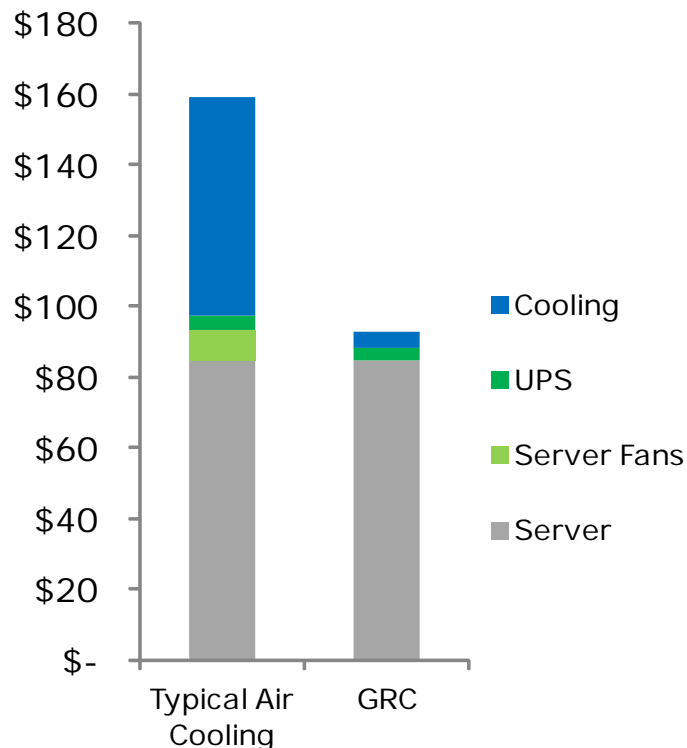




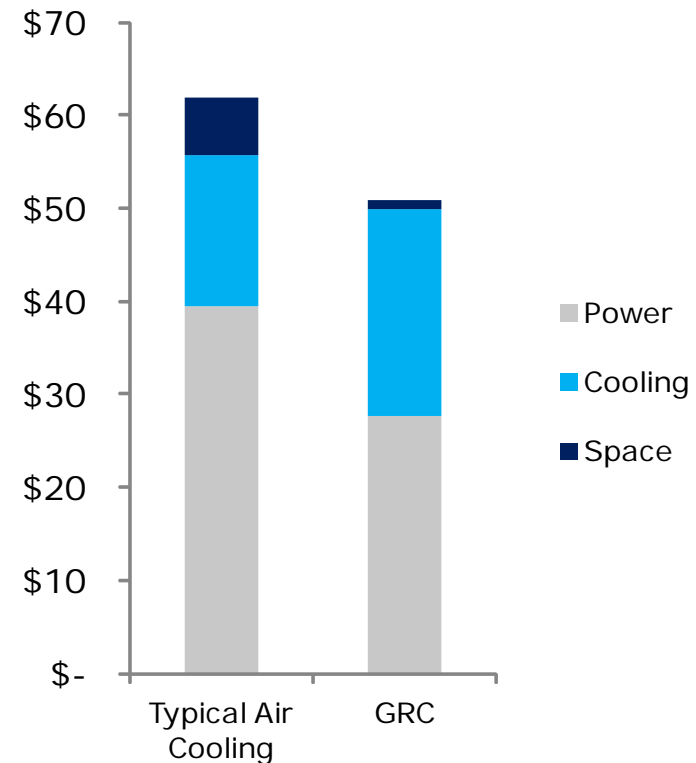
The CarnotJet™ System Offers Net Savings of \$77K per Rack



Lifetime Energy Cost/Rack*



Lower Infrastructure Cost



* 10 yr data center life, \$.075/kWh, 9% discount rate, 3% annual energy price, 20kW rack

† For single 20kW rack



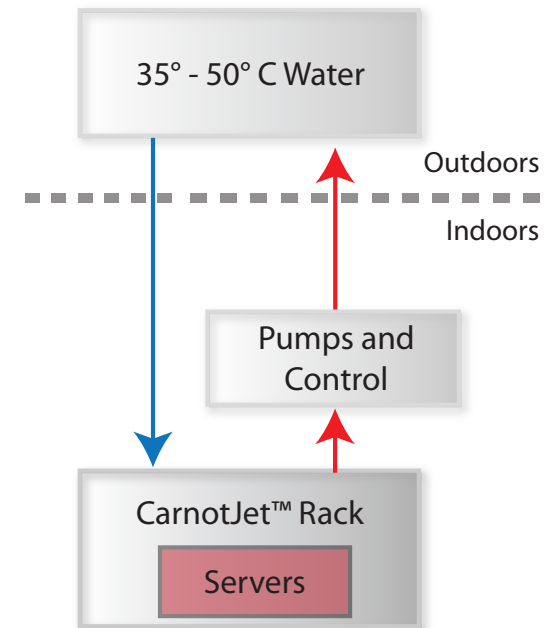
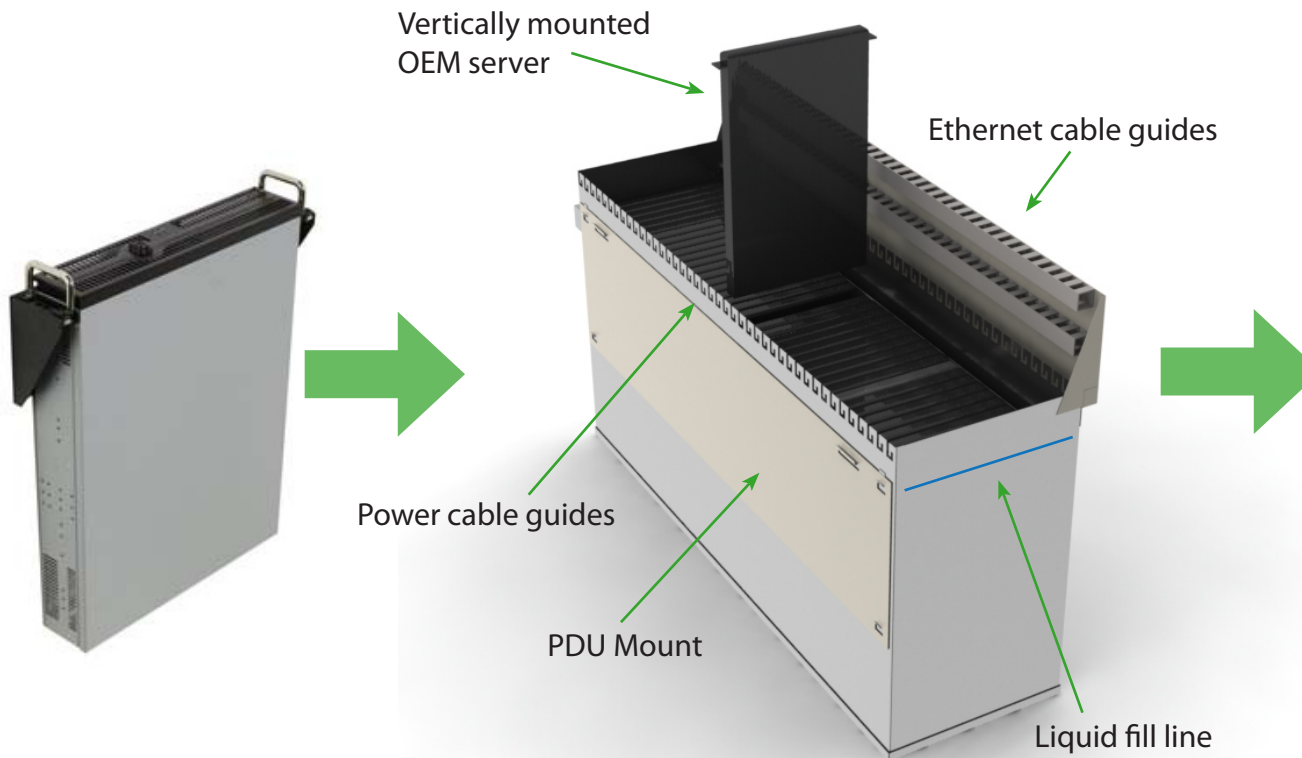
The CarnotJet™ System



Any OEM Server

CarnotJet™ 42U Rack

Heat Flow



Install any standard OEM rack server

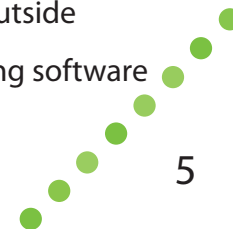
- » Any brand
- » CPU and GPU compatible
- » Fiber and InfiniBand compatible

Submerge into GreenDEF™ liquid

- » Captures 100% of heat
- » Requires no air cooling

Intelligent control system

- » Heat expelled outside
- » Alerts/monitoring software





How We Save Energy



Computers can function at 45°C (113°F)

Hard drives are limiting factor: reliable up to 45°C*

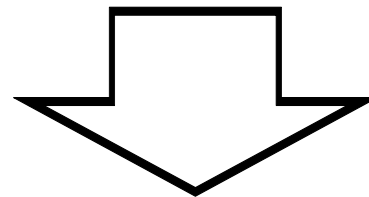
Intel CPU reliable at 75°C (167°F)

Air is a poor heat conductor

Must be kept at 25°C (77°F) (using ~7°C [45°F] chilled water) to cool servers

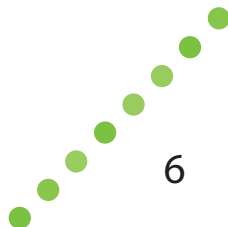
GreenDEF™ at 38°C (100°F) is just as effective as 25°C (77°F) air

Coolant transfers more heat at greater effectiveness



Easy to keep GreenDEF™ at 38°C (100°F). Energy intensive to cool water to ~7°C (45°F).

* Google study: Failure Trends in a Large Disk Drive Population, Barasso (2007)





Fewer Infrastructure Requirements



Air Cooling

CarnotJet™

CRAC/CRAH	●	○	
Chiller	●	○	
Large Backup Generator*	●	◐	● Required
Air-Flow Engineering	●	○	○ Not used
Hot/Cold Aisle	●	○	◐ Half-sized
Raised Floors/Special Floors	●	○	
Rack Rails	●	○	

*Generator proportional to power



Why it Works: Dielectric Liquid



GreenDEF™ Coolant:

Proven:

- » Long history of liquid submersion technology in the computing and electric power industries
- » More than 500,000 hours of server time logged in the CarnotJet™ system by our customers over the past two years

Powerful:

- » Virtually unlimited heat density and scalability for the future

Non toxic:

- » Not hazardous to humans
- » Similar formulations of white oil used in cosmetics

Server Support:

The CarnotJet™ system will support any OEM server after three simple modifications:

- » Removal of server fans
- » Replacement of thermal grease with foil alternative
- » Encapsulation of hard drives

Server Warranty:



Green Revolution Cooling has partnered with **Signature Technology Group**, a leading full service IT support company, to offer warranty on all OEM servers installed in our dielectric liquid submersion cooling systems.

Additional Advantages

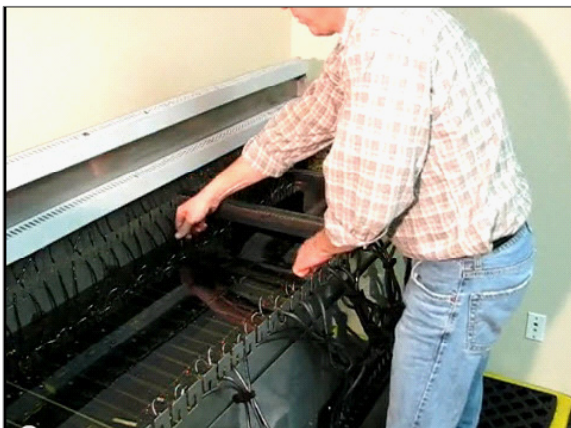


Increased server reliability

- » No server fans
- » Enhanced electrical connector reliability
- » No hot spots and no dust accumulation
- » Hard drives subjected to much less vibration resulting in fewer read/write errors

Easy Server Removal and Maintenance

- » Rack features a lift-up cover for quick access
- » Fluid drains off quickly, units can be serviced immediately (no drying required)
- » Typically requires 60 seconds to swap DIMM memory stick



Step 1: Select server

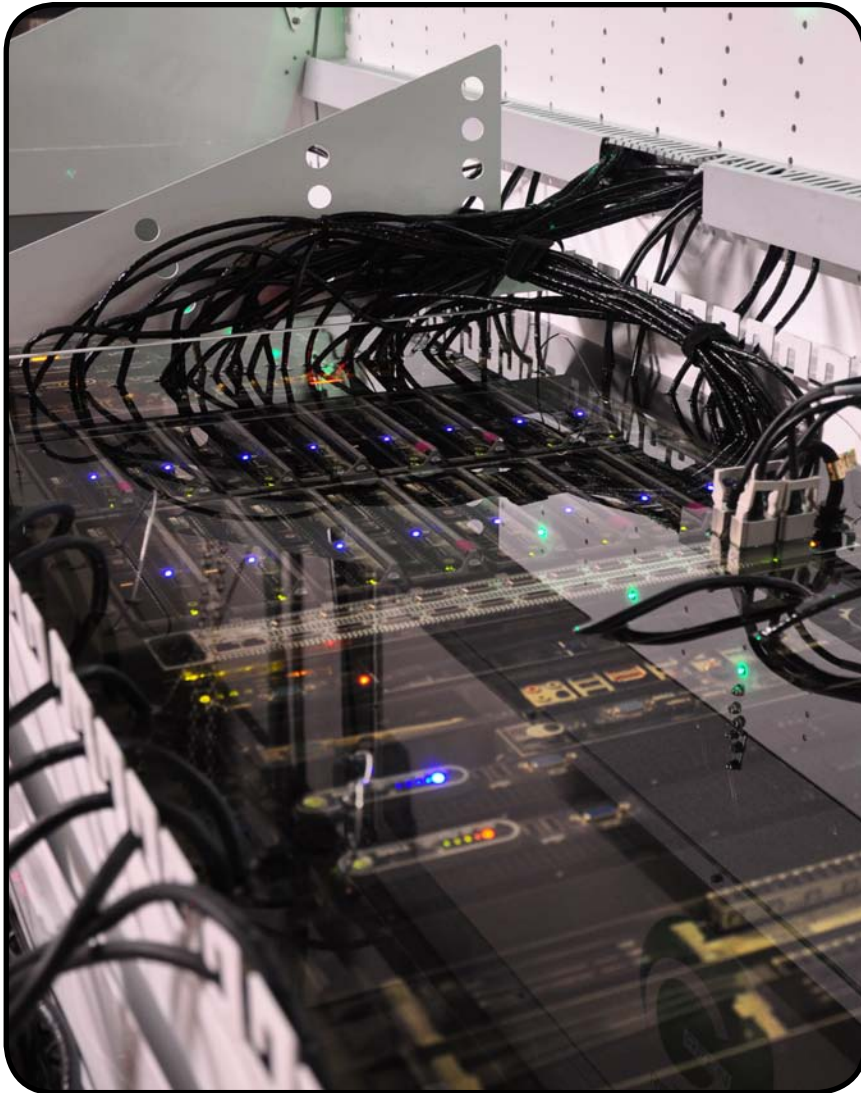


Step 2: Lift; fluid drains off



Step 3: Place server on service rails, draining continues

Case Study: Texas Advanced Computing Center†



Installation Facts:

Fluid-submerged Blade System (Dell M1000e) and various 1U servers

April 2010 installation, 100% system uptime

40% less total energy consumption (servers + cooling)

PUE* = 1.03

10-20% less server power (fan removal)

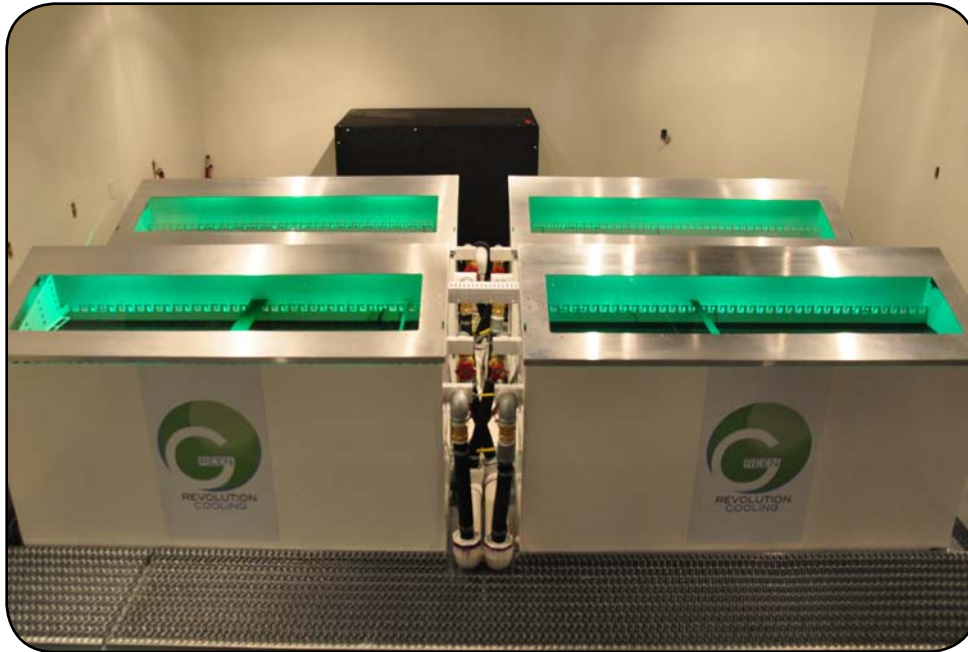
PetaFlop installation in planning stages for Q1 2012 (65kW and 252 GPUs per 42U rack)

Install Location	Loading dock
Room Climate Control	Unconditioned
Rack Size	42U
Rack Area	~1.2 m ²
Heat Load Capacity	40 kW
Servers Installed	M1000e blade chassis
Secondary Containment	Modular
Heat Exchange Method	Evaporative cooling tower

† Texas Advanced Computing Center [TACC] currently houses *Ranger*, #15 on the Top 500 supercomputing list.

*PUE is (cooling power + server power) / (server power)

Case Study: Midas Networks



Installation Facts:

Dec 2009: 8U beta install

Jan 2011: four rack, 100kW installation,
100% continuous system uptime

50% less energy than air-cooled system

10-20% less server power (fan removal)

PUE* = 1.03

Fully installed four rack system significantly
lower cost than air-cooled system

Install Location	Production space
Room Climate Control	Comfort cooling
Rack Size	4 x 42U
Total Rack Area	~11.2 m ²
Heat Load Capacity	100 kW (25 kW per rack)
Servers Installed	1U servers
Secondary Containment	Berm/Catwalk system
Heat Exchange Method	Redundant evaporative cooling towers

“ We wanted the ability to cool blade servers and other next generation technology, and that was not going to be practical with air-cooling. ”

--Kenneth Tooke, President, Midas Networks

*PUE is (cooling power + server power) / (server power)



Cost effective

Save \$77,000 per rack, lifetime, compared to
a standard air-cooled solution

Environmentally friendly

Most efficient solution available

Powerful

Up to 100kW per rack

Find out more at www.grcooling.com