

Hyperefficient Data Centers for Deep Decarbonization of Large-scale Computing

Saeed Moghaddam, U. of Florida

COOLERCHIPS Kickoff
Meeting
October 18 & 19, 2023

Total Project Cost:	\$3M
Length	36 mo.

Brief COOLERCHIPS Project Overview

Team member	Location	Role in project, core competencies
University of Florida	Gainesville, FL	Lead, heat sink and system design and integration
Boyd Corporation	Laconia, NH	Manufacturing, liquid cooling and phase change
University of Maryland	College Park, MD	Reliability assessment
NREL	Golden, CO	Packaging and DC-level testing

Project Vision

- 126 kW rack with 1000 W chips operating at PUE < 1.04, with ~70 °C exit primary loop temperature
 - Enabled by a unique water phase-change heat sink @ ~1 MW/m².K
- Reducing TCO while providing high quality waste heat for heating (space and water) and cooling (via operating heat-driven chillers)
 - Particularly attractive for EDGE computing

Team Members



Saeed Moghaddam
Professor
Organization: U. of FI



Sukhvinder Kang
Chief Technology Officer
Organization: Boyd



Nelson Gernert
VP Eng. and Tech.
Organization: Boyd



Jerome Toth
Sr. Vice President, Eng. & Tech.
Organization: Boyd



Patrick McCluskey
Professor
Organization: UMD



David Sickinger
HPC Projects Oversight
Organization: NREL



Gilbert Moreno
Sr. Res. Eng.
Organization: NREL



Sreekant Narumanchi
Sr. Manager
Organization: NREL

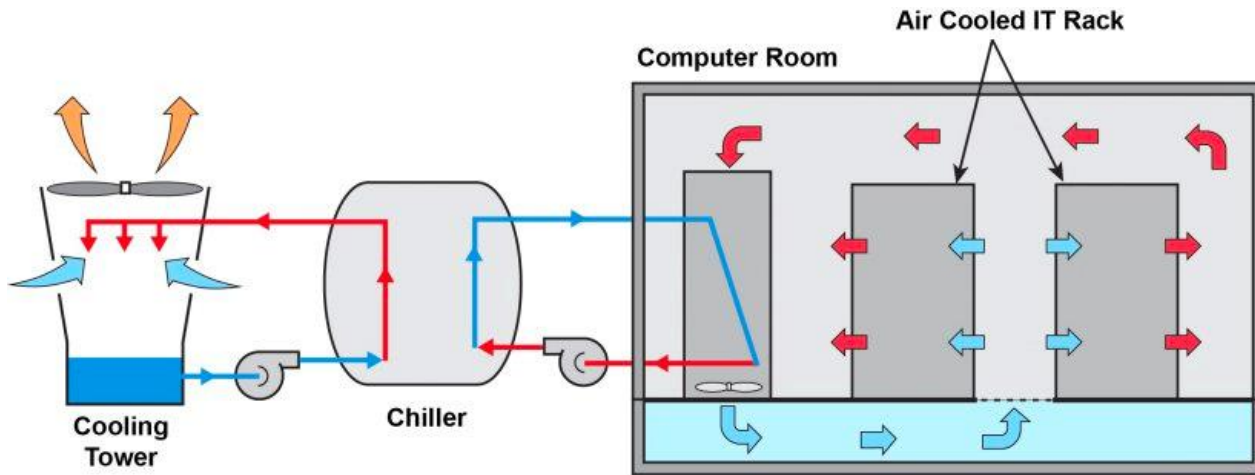


Douglas DeVoto
Title: Sr. Res. Eng.
Organization: NREL

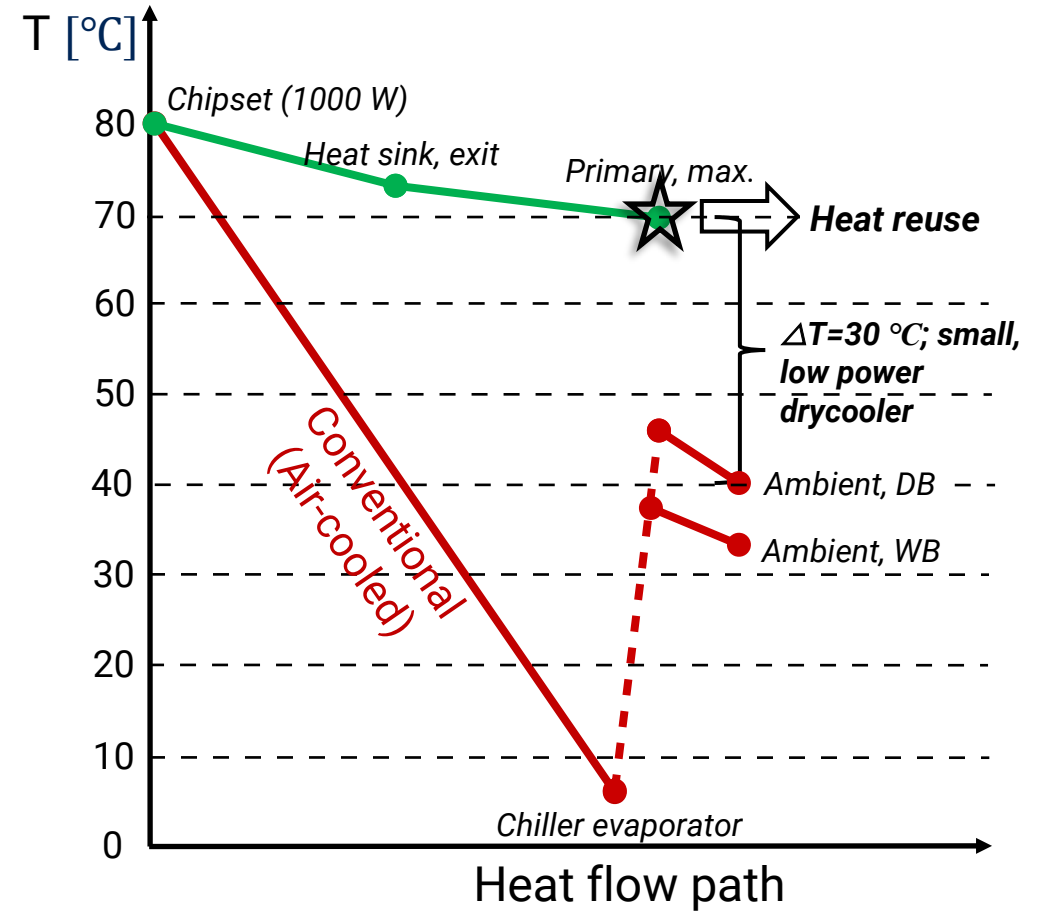


Paul Paret
Title: Sr. Res. Eng.
Organization: NREL

Objective

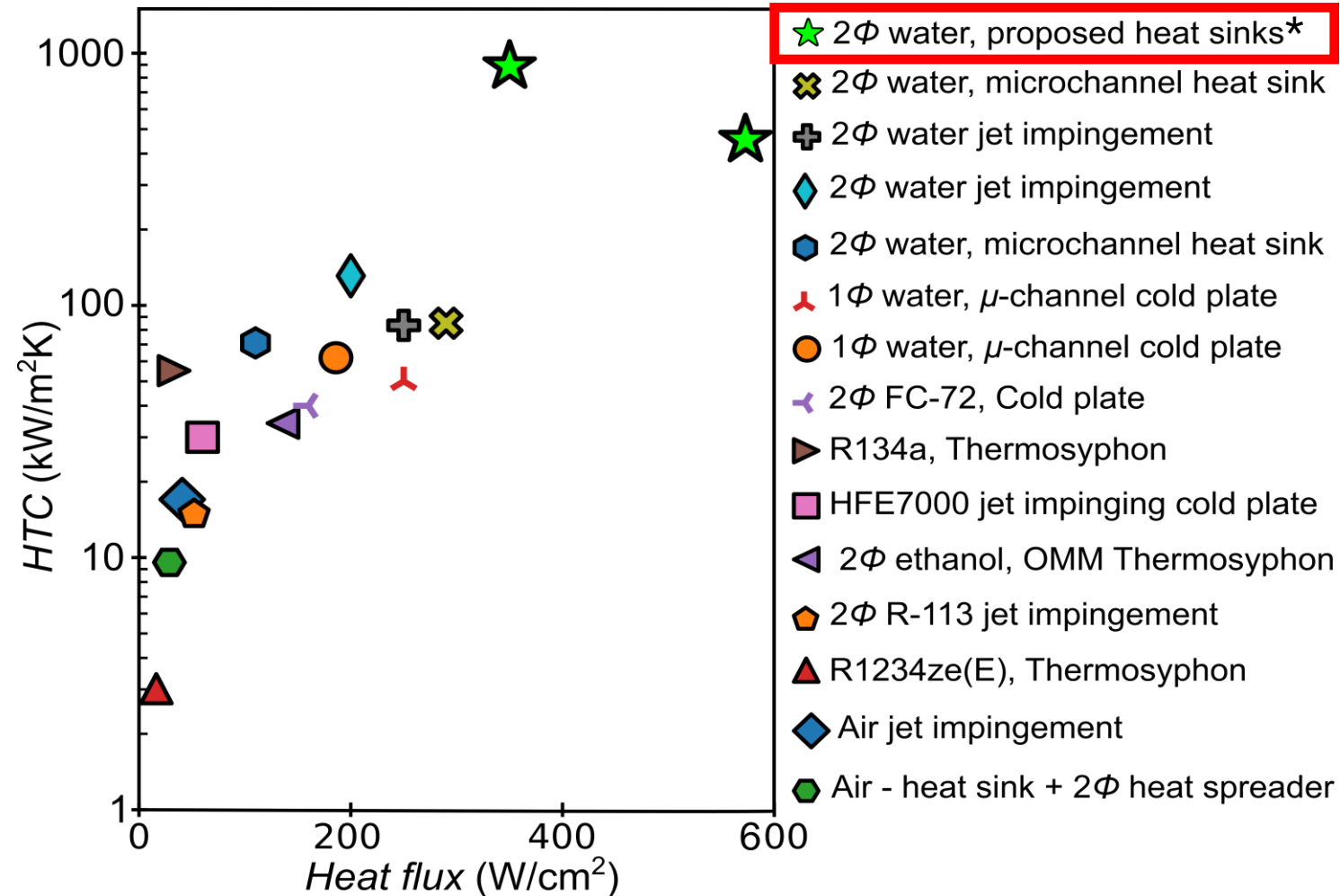


Conventional Air-cooled DC



Innovation

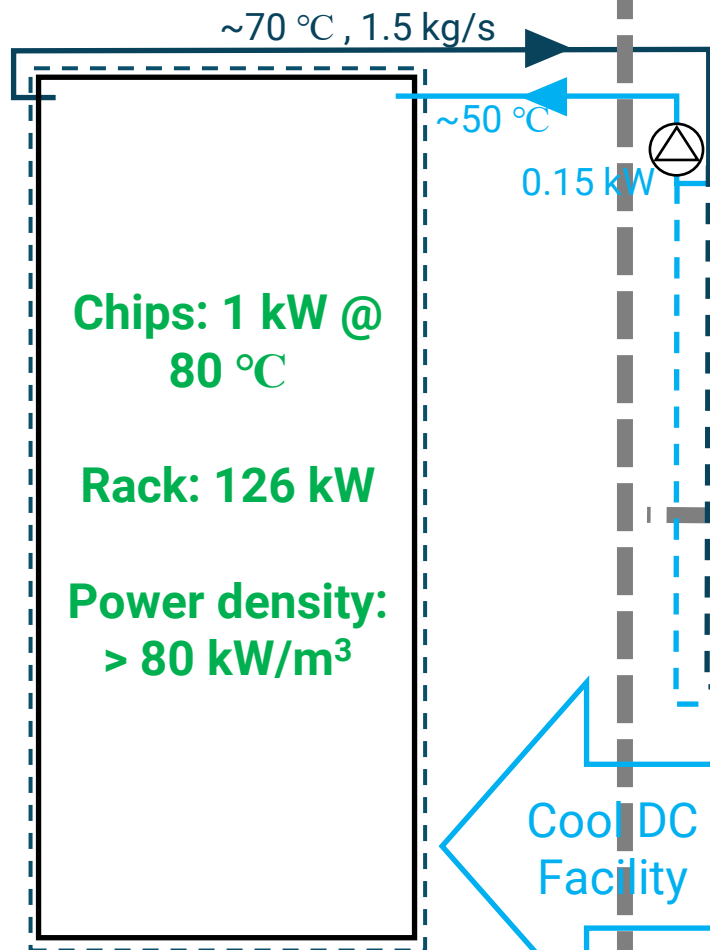
- Current chips:
~100 W/cm²



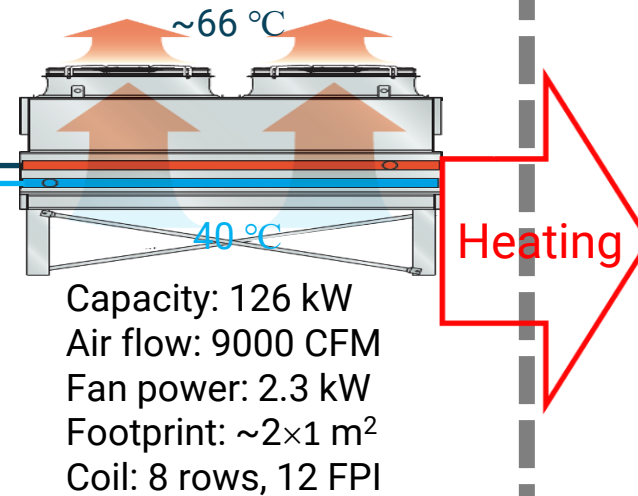
* Data collected at $T_{\text{sat}} = 55 \text{ }^\circ\text{C}$ (increases to $\sim 1800 \text{ W/cm}^2$ @ $T_{\text{sat}} = 100 \text{ }^\circ\text{C}$)
- All 2Φ heat sinks operating at $T_{\text{sat}} < 60 \text{ }^\circ\text{C}$.

System Configuration & Performance

COOLERCHIPS Program



Existing Technology



Future Programs

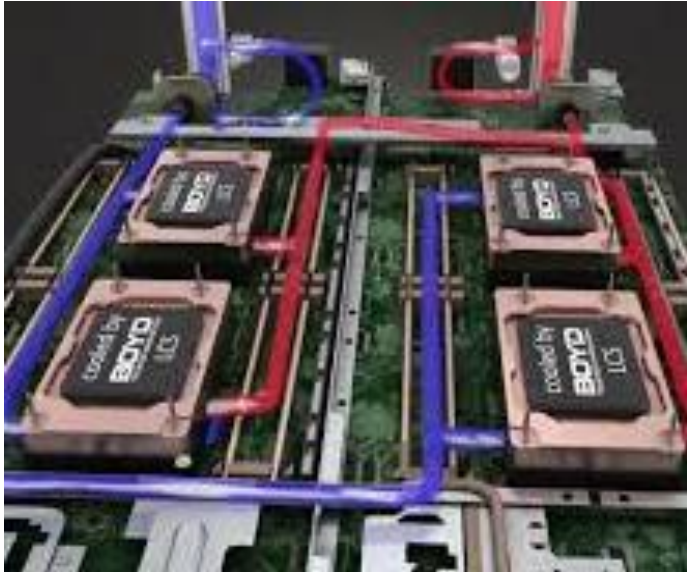


EDGE Computing (Utilizing Waste Heat)



Tasks & Schedule

**Year 1
(chip/ server-level
integration)**



**Year 2
(Rack-level integration/
validation)**



**Year 3
(Demonstration at
data center)**



Reliability assessment, enhancement, modeling, Digital Twin (DT)

Technoeconomic modeling

Test Case: NVIDIA AI Technology Center at UF (NVAITC-UF)



- 3.2 MW, PUE ~ 1.6, serving Florida higher education institutions
- First in North America; a joint research center of NVIDIA and UF for advancing Artificial Intelligence (AI) education and research, as well as fostering partnership between higher education and industry.

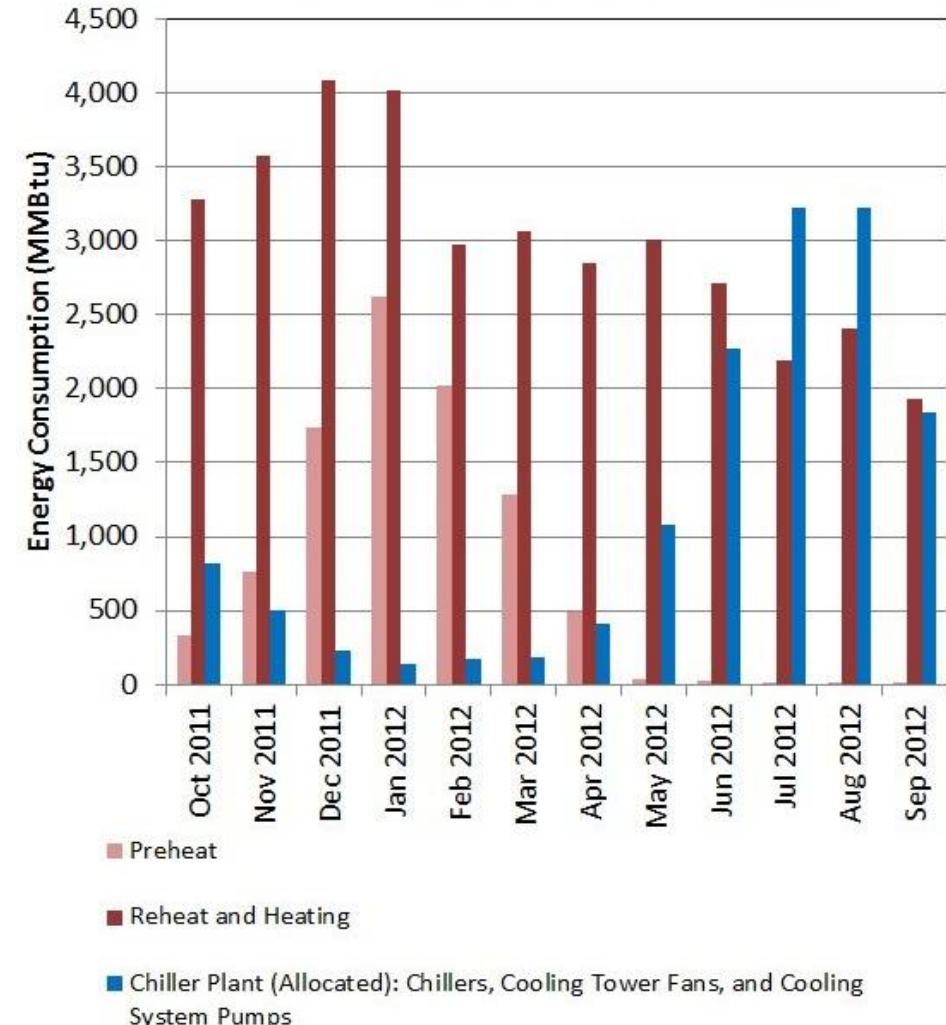
Value Proposition:

- Eliminates the chiller plant and AHUs
 - Account for ~50% of facility footprint
- Higher server density per rack reduces white space by ~70%
 - Replace 40 (~40 KW) racks by 13 racks
- No water use in cooling towers
- Zero GWP coolant
- Silent operation
- > 70% of waste heat can be recovered and reused for district heating (when possible) or operating heat-driven chillers
 - Currently HPs are use to elevate temperature from ~30 °C to 60-80 °C, depending on system requirements and climate.

Market Opportunities (EDGE Computing – heat reuse)



MGH Gray Building: Heating and Cooling



Energy consumption associated with HVAC system in Massachusetts General Hospital (MGH) Gray building

Technology to Market (T2M) Plan

- Finalize reliability and failure models, cost/ performance models, marketing collateral
 - Market demand survey, adoption challenge and opportunity analysis
- Business plan for Board approval
 - Technoeconomic analysis, value proposition, risk analysis
 - Required capital and ROI analysis
 - Materials and components Supply Chain analysis
 - Manufacturing ramp & scaling analysis
 - FIT models and insurance, warranty, and service cost analysis
- Regulatory
 - Safety compliance testing and certifications

Q & A



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