OCP SUMMIT

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Engineering Workshop: Advanced Cooling

Solving the Energy Challenge through Innovations in Data Center Cooling

3m.com/immersion **Booth# B44**

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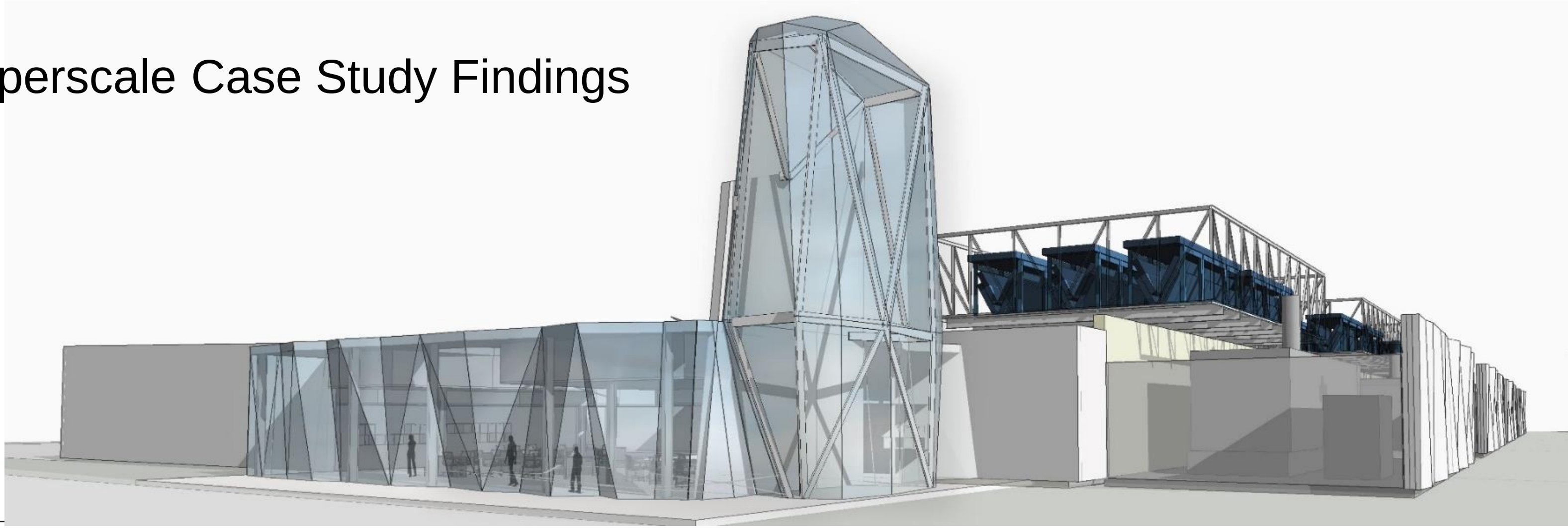
ALLIED CONTROL IMMERSION COOLING Kar-Wing Lau, CEO

STRUCTURETONE Charles Benge, Director Mission Critical

Agenda

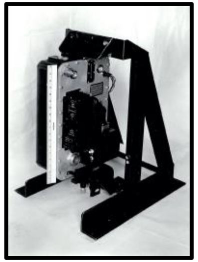
- Immersion Cooling Technology Introduction
- 3M Roadmap for Immersion Cooling at Open Compute
- Hyperscale Case Study Findings



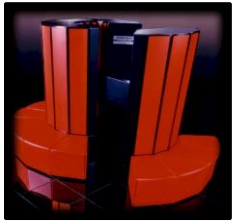
Immersion Cooling Approach

Fluorochemical (FC) Fluids in Electronics Cooling :

- Non-flammable / Non-combustible
- Excellent Safety Profile
- Chemically Inert
- Electrically Non-Conductive
- Wide Range of Boiling Points



Radar Klystrons and Military Test Methods Developed around FC Fluids.

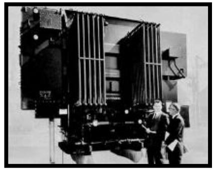


Cray Begins using FC Fluids for Immersion Cooling of Supercomputers

Allied Control Deploys 2-Phase Immersion with FC Fluids at 40MW Scale for Bitcoin Mining

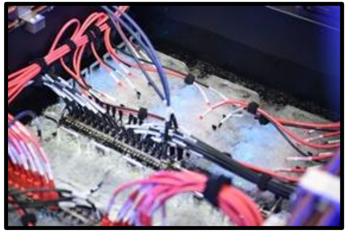
1950 1960 1970 1980 1990 2000 2010 2020

FC Fluids Used for Immersion Cooling of Commercial Transformers



IBM, 3M and Purdue Pioneer Use of 2-Phase Immersion with FC Fluids

Alibaba’s project Qilin paves the way for First Hyperscale X86 Deployment



Open Compute Roadmap

- Leverage OCP Data Center Project to help form immersion cooling ecosystem
- Seek collaborators to participate and contribute designs, best practices
  - IT hardware, mechanical systems, facility designs, power delivery
- Today: Hyperscale Case Study Findings
- Near Future: Immersion cooled power supply

Power Supply Concept

Conventional air cooled commodity AC power supplies are not ideal for immersion and all power supplies are thermally limited. Expected modifications:

- Firmware – modify to operate without fan tach and at elevated temp
- Density – A typical PSU is about 80% air, adding fluid cost and weight
- Organic Contaminants – PSUs often contain solder flux, conformal coatings, silicone elastomers, hot melt adhesives, etc
- Heat sinks required for air cooling of MOSFETs are unnecessary
- Electrical coatings, potting and Isolation pads are unnecessary in filtered liquid dielectrics
- Current capacity ratings – The current capacity of circuit traces, FETs and resistors are driven by thermal considerations that shift in an immersion environment in ways that can reduce cost

See demo at booth B44

OCP Deliverable: Immersion cooled AC power supply specification and concept
Future path to immersion cooled on-board power module

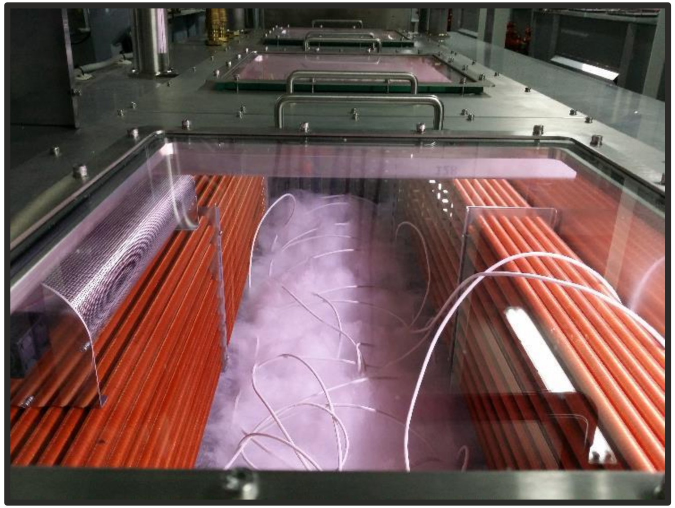
Expected Benefits: Lower cost/KW; Higher density; Reduced BOM

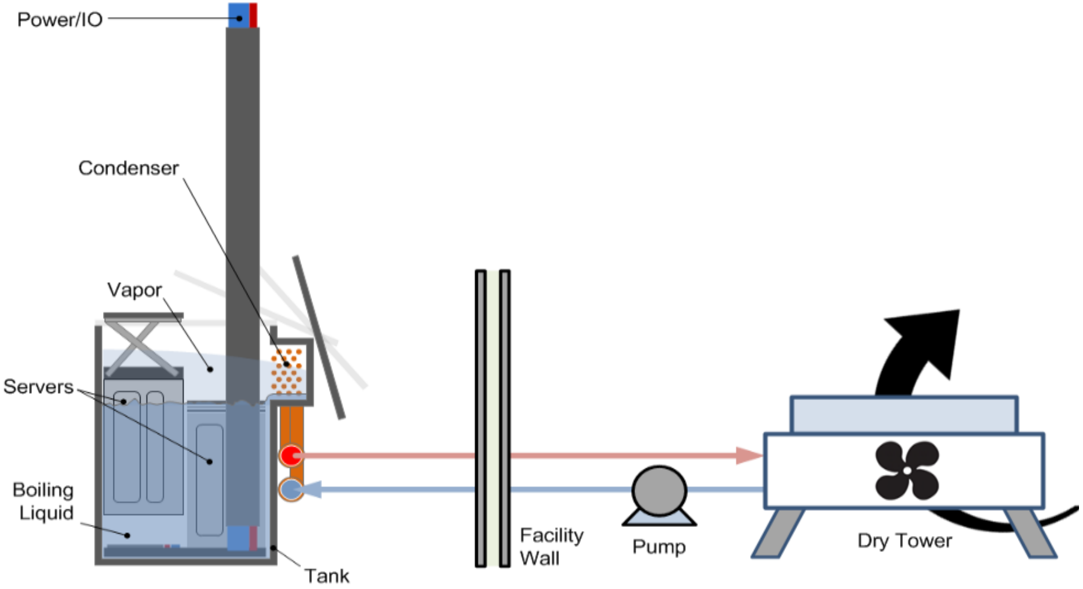
Case Study

Immersion Cooling Approach

Passive 2-Phase Immersion Cooling :

- Servers are placed side-by-side in a lidded bath of dielectric fluid.
- Devices cause fluid to boil.
- Rising vapor condenses transferring heat passively to facility water.





Project Requirements :

- 30 MW IT Load
- Hyper-scale deployment
- (4) 7.5 MW Data Halls
- Potential phased delivery
- Des Moines, IA
- 10 kW Avg. Air-cooled Rack
- 150 kW Avg. Tank
- Tier 3 Uptime Reliability

Comparison Criteria

Physical Metrics

- Acreage required for Site Development
- Gross Building Square Footage
- Data Hall Square Footage
- Watts per Square Foot

Construction Cost

- Total Cost built as single phase
- Cost per MW
- Cost per Square Foot
- Sub-system breakdown
- Focus on Mechanical and Electrical
- Labor rates for specialized systems

Construction Schedule

- Total Construction Time
- Equipment Procurement Time
- Labor Manpower

Mechanical and Electrical Systems

- Reliability
- Efficiency
- Practicality

Telecom / Compute

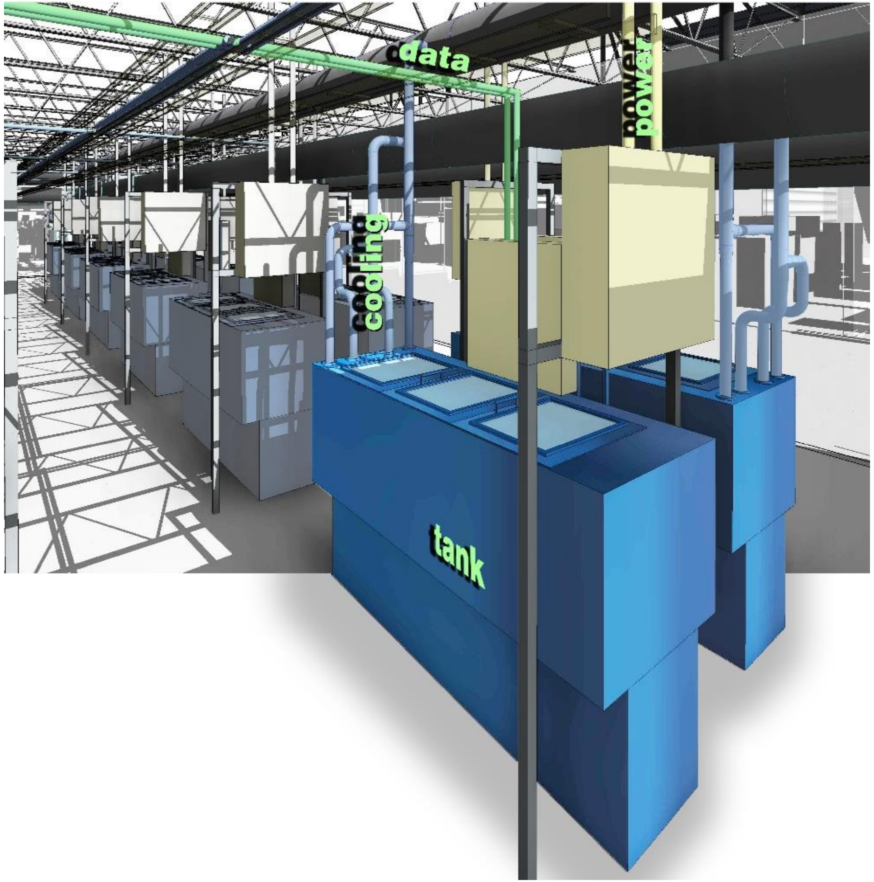
- GPU Server Architecture
- Density
- Server
- Cost per Compute - TBD

General

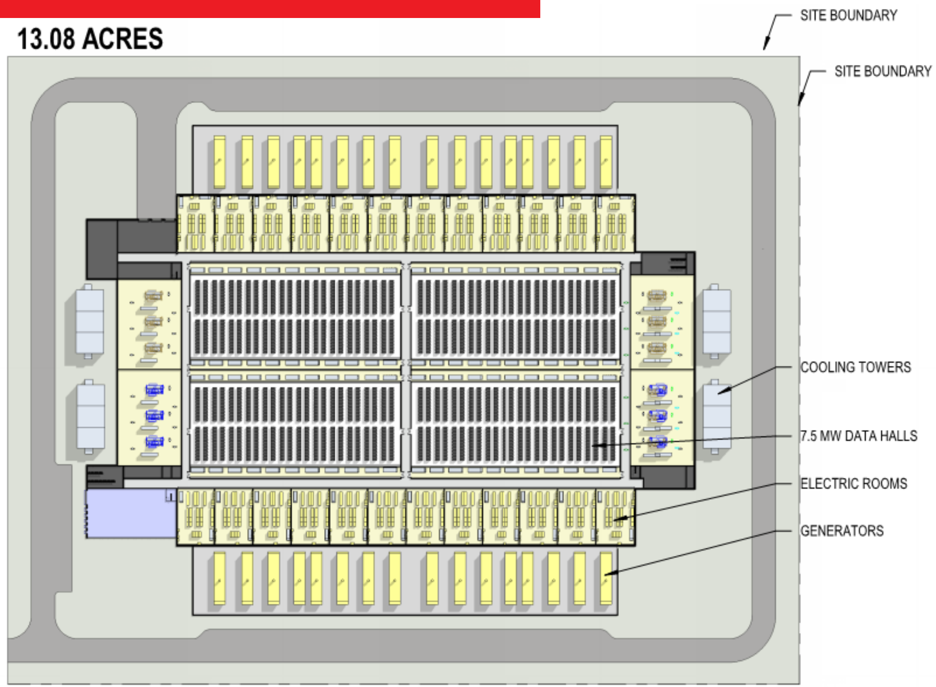
- Complexity/Simplicity
- Perception of Feasibility
- OpEx - TBD
- Sustainability
- Applicability

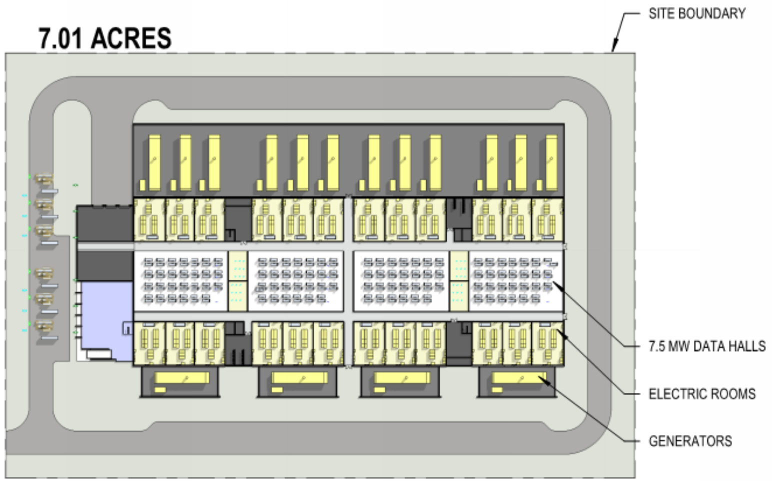
Immersion Cooling Module

- Tank Dimensions 7’-8” W x 2’-6” D x 5’-4” H
- Power, Process water and Telecom from above
- No raised floor needed, simplifying construction
- Much lower room height without any air plenum
- 150kW planned capacity per Tank
- Busbar system in bottom of Tank
- Ample white space around each tank, could be even higher density



Facility Comparison





Air-cooled Hyper-scale

- (4) 20,160 sf Data Halls
- Average 10 kW / cabinet
- 864 Cabinets / Hall
- **3,456 Cabinets Total**

Admin/Circulation	32,779
White Space	80,640
Direct Support	106,894
Total SF	**220,313**
WSF	**370**

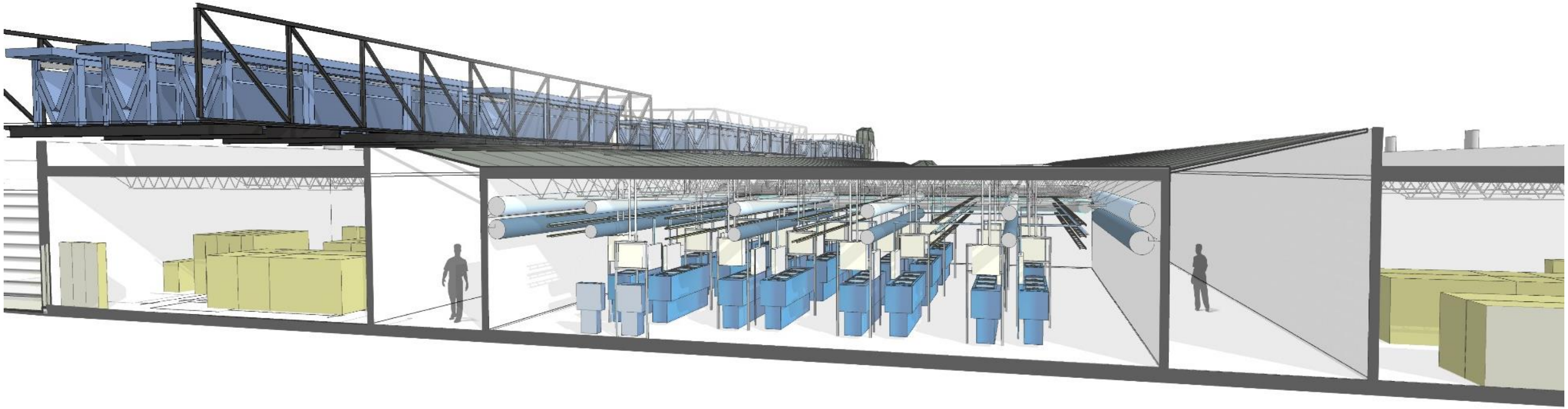
Immersion Cooled

- (4) 6,604 sf Data Halls
- Average 150 kW / Tank
- 54 Tanks / Hall
- **216 Tanks Total**

Admin/Circulation	24,718
White Space	26,416
Direct Support	38,120
Total SF	**89,254**
WSF	**1,100**

Building Configuration

- Roof mounted Mechanical equipment
- No ceiling air plenum = reduced roof height
- Roof penetrations possible



Electrical Topology

- Simplified Electrical topology provides more reliability
- Tier 3 design
- 2.5 MW cell with single generator
- High density tanks require fewer electrical connections per kW
- Fluid is an insulator and reduces arc-flash risk
- 277V distribution provides reduction of electrical components such as PDU, RPP and busway
- 277V is a U.S. standard

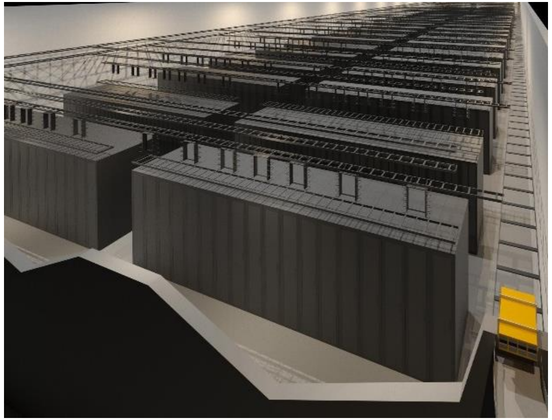
	Air cooled	Immersion cooled
IT Load	30 MW	30 MW
Phasing	(4) 7.5 MW Data Halls	(4) 7.5 MW Data Halls
Increment	(3) 2.5 MW cells / Hall	(3) 2.5 MW cells/per Hall
Backup	(2) Parallel 2250 Gensets	(1) 3250 Genset (w/ Catcher system)
Main Switchgear	5000A	4000A
UPS	(5) 500 kVA UPS Modules	(4) 700 kVA UPS Modules
UPS Distribution SWB	4000A SWB	4000A SWB
PDU	(4) 750 kVA PDU’s	N/A
Distribution	240V Distribution	277 U.S. Standard
Server Connection	Plugin Busway	Direct to server
Total Mechanical Load	11 MVA	3 MVA
Estimated Site Load	41 MVA	33 MVA

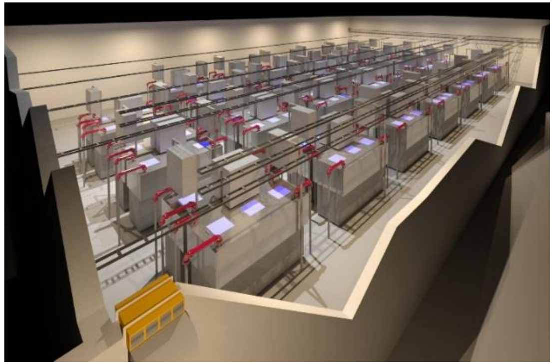
Mechanical Topology

- Simplified Mechanical topology provides more reliability
- Tier 3 design
- No chillers with economizers and complex controls
- Removal of chillers eliminates need for major, time-consuming PMs and overhauls
- High density tanks are passive mechanical devices
- Water temperature in many climates allows for full capacity cooling without evaporation infrastructure
- Opportunity for heat recovery with Process Water

	Air cooled	Immersion cooled
IT Load	30 MW	30 MW
Phasing	(4) 7.5 MW Data Halls	(4) 7.5 MW Data Halls
Data Hall Cooling	(22) 372 kW CRAHs / Hall Requires Containment	(54) Passive immersion tanks / Hall (2) 5 ton FCUs / Hall
Cooling Plant	WC Chiller Plant / Hall	Dry Coolers / Hall
Chillers	(3) 1280 Ton WCC	None
Pumps	(9) CHWP, CWP, CWBP	(9) Process Pumps
Cooling Towers	(3) 1280 Ton Evaporative	(9) Dry coolers
Water Temp	CHW: 60 F / 76 F	Process: 112 F / 127 F
PUE	1.23	1.07
Estimated Annual Electricity Cost	$19.4M	$16.9M
Estimated Annual Water Consumption	299 Mgal (MU + WW)	0 Gal
Estimated Energy Cost	$21.05M	$16.9M

Telecom Comparison





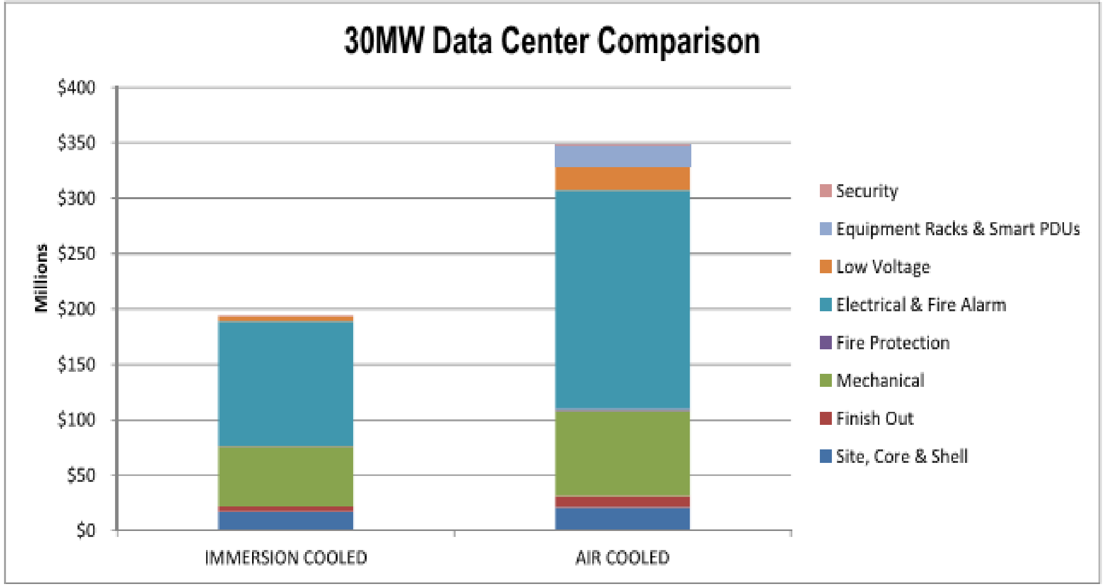
	Air cooled	Immersion cooled
Server Housings	864 Cabinets per Data Hall **3,456 Cabinets**	54 Tanks per Data Hall **216 Tanks**
Servers	13 (2 GPU) per Cabinet 11,232 per Data Hall **44,928 Servers**	48 (8 GPU) per Tank 2,592 per Data Hall **10,368 Servers**
Prod Switches (A+B)	2 per 3 Cabinets 576 per Data Hall **2,304 Switches**	2 per Tank 108 per Data Hall **432 Switches**
Connectivity	1 Gb Cat6 (Servers to Switch) 10 Gb 6MMF MPO (Switch to Core)	10 Gb Cat6 (Servers to Switch) 100 Gb 24MMF MPO (Switch to Core)
Telecom ROM	$16.3M (hard cost)	$3.7M (hard cost)

Cost Comparison

$4.8M per MW less expensive than traditional Air-Cooled Server Data Center

- $195M Immersion v. $348M Air-cooled
- No need for PDUs, RPPs, Busway or CRAH/CRACs in Data Center Space
- Tanks eliminate traditional cabinets and reduce fiber & copper cabling needs
- Better Utilization & Efficiency of Electrical & Mechanical systems Reduce Equipment Counts without sacrificing Redundancy

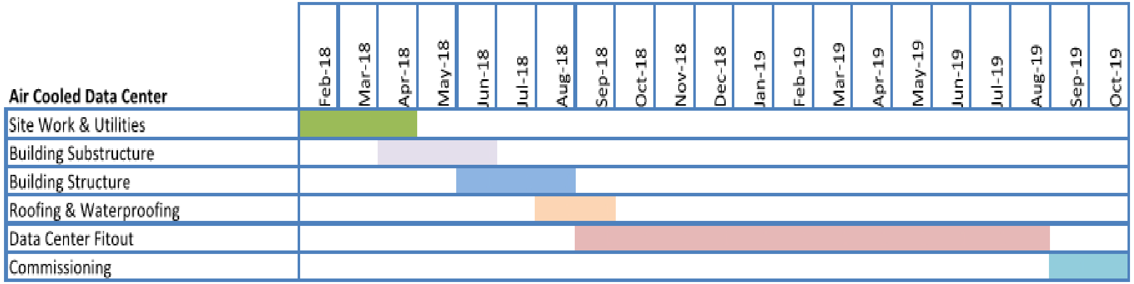
Pricing Recap	IMMERSION COOLED	AIR COOLED
Site, Core & Shell	$16,887,369	$20,751,085
Finish Out	$4,817,688	$10,433,781
Mechanical	$54,298,079	$77,131,315
Fire Protection	$623,705	$1,423,644
Electrical & Fire Alarm	$112,199,766	$197,416,000
Low Voltage	$4,707,808	$22,312,241
Equipment Racks & Smart PDUs	$0	$17,852,446
Security	$936,464	$1,090,335
Total	$194,470,879	$348,410,846

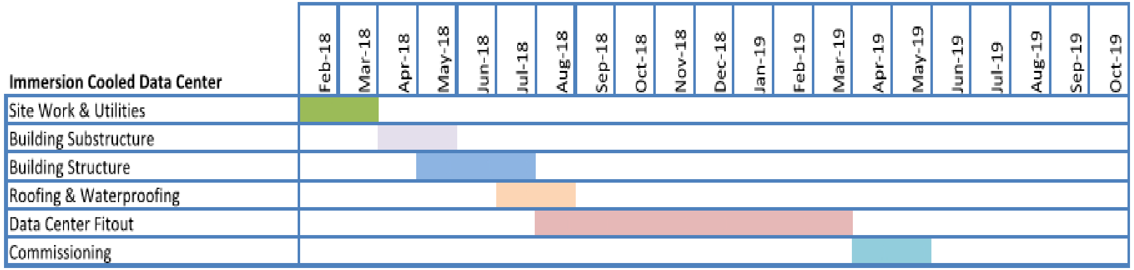


Schedule Comparison

30% Construction Schedule Reduction

- Reduced Site & Structural Construction Compared to Traditional Build of Equal Computing Power
- Less “Long Lead” Equipment
- Fewer Pieces of Critical Equipment in Data Hall Space





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