LIFECYCLE ANALYSIS ON AIR COOLED AND OIL COOLED SUPERCOMPUTERS:

An Industry-Driven Approach

Group members:

- Sivakumar, Sakthikumar
- Olayinka, Bukky R
- Vattikuti, Harnika
- Killampalli, Sai Charan
- Subramanian, Arun

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Problem Statement

Ideal Situation: The industry demands supercomputers with cutting-edge cooling systems that optimize efficiency and sustainability. However, current cooling methods may not fully align with the industry's growing need for cost efficiency and environmental responsibility.

The critical gap lies in the absence of a comprehensive analysis comparing the economic impacts of air-cooled and immersion cooled supercomputers.

Approach: To bridge this gap, our study rigorously evaluates and compares critical financial metrics, including present worth, future worth, annual worth, internal rate of return (IRR), break-even point, and total cost of ownership (TCO) between Supermicro's air-cooled system and DUG's immersion-cooled system. Our goal is to provide a well-informed recommendation on which system is the superior choice, considering both economic and environmental factors.

Methodology

Comprehensive Data Collection:

Multifaceted approach encompassing financial, operational, and environmental aspects for both air-cooled and oil-cooled supercomputer systems.

Extended Analysis for Immersion System:

In-depth examination beyond basic cost analysis for the oil-cooled immersion system, including additional component prices for complete functionality.

Financial Metric Assessment:

Utilization of key financial metrics such as present worth, future worth, annual worth, break-even point, IRR, and total cost of ownership for robust comparative analysis.

Long-Term Economic Viability Focus:

Comparative analysis extends beyond immediate costs, emphasizing long-term financial performances to assess the overall economic viability of each system.

Holistic Lifecycle Impact Evaluation:

Comprehensive framework considers costs, revenues, energy consumption, and environmental impact to guide a well-informed acquisition decision.

Cost Calculation: Dug's system

Components to be added

component	quantity	price
SuperServer 1029P-WTRT - 1U - 10x SATA - Dual 10-Gigabit Ethernet - 12x DDR4 - 750W 1+1 Redundant	1	$5007.00
Dielectric Coolant - 3M Novec 7000 Engineered Fluid 10 lb / 1 Gal Bottle 3M #7100003719	1 gal	$780.00
Tank-Powerful Immersion Liquid Cooling 40KW	1	$1280.00
Grundfos Circulation system - Brute 1/6hp	2	$719.00
Brazed Plate Heat Exchanger, AISI 316L, Stainless Steel, 13 Plates -Domestic Heating 130k BTU	1	$361.99
Temperature sensor ifm efector TN2333	1	$348.75
Miscellaneous		$3000.00
Total = $11,494.24		

Components to be excluded

Components	Price
(PWS-DF005-2F) -fan module	$156.76

Supermicro's air cooled system Quote = $122317.09

Therefore, total initial cost for DUG system

= $122317.09+$11494.24 - $156.76
= **$133657.57**

Operating Cost Calculation

Dug's immersion cooled system:

Number of Pumps per Tank: 2
Electrical Supply: 1 phase, 240 V, 50/60 Hz
Max Current per Pump: 1.1 A
Power (kW) = Voltage (V) × Current (A)/1000

For one pump:
Power per Pump (kW) = 240V × 1.1A/1000 = 0.264 kW

For two pumps:
Total Power per Tank = 0.264 kW × 2 = 0.528 kW

To find the annual energy usage, we multiply the total power by the number of hours in a year:

Hours in a Year: 24 × 365.25 = **8766 hours**
Annual Energy Usage per Tank = 0.528 kW × 8766 hours = **4631.968 kWh**
Assuming the cost of electricity is **$0.12 per kWh**,
Annual Operating Cost per Tank = 4631.968 kWh × $0.12/ kWh = **$555.41**

Supermicro's Air-cooled system:

The power supply unit (PSU) has an output power of 2880 Watts or 2.88 kW. (given in manual)

Annual Operating Cost = Power in kW × Hours per Year × Electricity Cost per kWh

Annual Operating Cost
= 2.88 kW × 8760 hours/year × $0.12 per kWh
= **$3027.456** per year

Justification for Discount Rate (7%)

- A **7%** rate strikes a balance between risk and return for many types of investments. It's higher than the risk-free rate but not as high as the rates used for high-risk investments. This makes it a moderate choice suitable for investments with average risk. For many companies, the WACC – which includes the cost of debt and the cost of equity – falls around this percentage. It represents the average rate that a company is expected to pay to finance its assets.

Present Worth of Two Alternatives

Dug's immersion cooled system:

Initial Cost	$133657.57
Operating Cost	$555.41
Discount Percent	7%
Lifespan (n)	13 years
Annual revenue	$20000.00

PW_{dug} = PV(7%,13,-20000,) - 133657.57

PW_{dug} = $33495.44

Supermicro's Air-cooled system:

Initial Cost	$122317.09
Operating Cost	$3027.46
Discount Percent	7%
Lifespan (n)	10 years
Annual revenue	$17527.95

PW_{sm} = PV(7%,10,-17527.95,) - 122317.09

PW_{sm} = $791.90

Annual Worth of Two Alternatives

Dug's immersion cooled system:

Initial Cost	$133657.57
Operating Cost	$555.41
Discount Percent	7%
Lifespan (n)	13 years
Annual revenue	$20000.00

$\mathbf{AW_{dug}}$ = PMT(7%,13,133657.57) + 20000

$\mathbf{AW_{dug}}$ = $4007.76

Supermicro's Air-cooled system:

Initial Cost	$122317.09
Operating Cost	$3027.46
Discount Percent	7%
Lifespan (n)	10 years
Annual revenue	$17527.95

$\mathbf{AW_{sm}}$ = PMT(7%,10,122317.09) + 17527.95

$\mathbf{AW_{sm}}$ = $112.75

Future Worth of Two Alternatives

Dug's immersion cooled system:

Initial Cost	$133657.57
Operating Cost	$555.41
Discount Percent	7%
Lifespan (n)	13 years
Annual revenue	$20000.00

FW_{dug} = FV(7%,13,-20000,133657.57)

FW_{dug} = $ 80718.83

Supermicro's Air-cooled system:

Initial Cost	$122317.09
Operating Cost	$3027.46
Discount Percent	7%
Lifespan (n)	10 years
Annual revenue	$17527.95

FW_{sm} = FV(7%,10,-17527.95,122317.09)

FW_{sm} = $ 1557.83

Internal Rate of Return Analysis with Two Alternatives

Supermicro's Air-cooled system:

Initial Cost	$122317.09
Operating Cost	$3027.46
MARR	7%
Lifespan (n)	10 years
annual revenue	$17527.95

IRR_{sm} = rate(10,-17527.95,122317.09)

IRR_{sm} = 7.14% > 7% MARR

- Since, supermicro's Air- cooled system is justified as its return exceeds the MARR, we compute the IRR on the incremental investment:

Difference in investment:	$11340.48

IRR_{diff} = rate(10,-(20000-17527.95),11340.48)

IRR_{diff} = 17.43% > 7% MARR

- Since, the IRR of the incremental investment is greater than 7% MARR, the need for investing in dug's system is justified.

Internal Rate of Return Analysis with Two Alternatives

Dug's immersion cooled system:

Initial Cost	$133657.57
Operating Cost	$555.41
Discount Percent	7%
Lifespan (n)	13 years
annual revenue	$20000.00

$\mathbf{IRR_{dug}}$ = Rate(13,-20000,132657.57)

$\mathbf{IRR_{dug}}$ = 11.20% > 7% MARR

Total Cost of Ownership

Dug's immersion cooled system:

Initial Cost	$133657.57
Operating Cost	$555.41
Discount Percent	7%
Lifespan (n)	13 years
annual revenue	$20000.00

Total Operating Cost = $555.41 X 13 years
= $7220.33

TCO_{dug} = $133657.57 + $7220.33

TCO_{dug} = $140877.90

Supermicro's Air-cooled system:

Initial Cost	$122317.09
Operating Cost	$3027.46
Discount Percent	7%
Lifespan (n)	10 years
annual revenue	$17527.95

Total Operating Cost = $3027.46 X 10 years
= $30274.60

TCO_{sm} = $122317.09 + $30274.60

TCO_{sm} = $152591.69

Break Even Point of Two Alternatives

Dug's immersion cooled system:

TCO_{dug} = $140877.90
Annual revenue = $20000.00

Break Even Point = TCO_{dug}/Annual revenue

= $140877.90 / $20000.00

Break Even Point = 7.04 years

Supermicro's Air-cooled system:

TCO_{sm} = $152591.69
Annual revenue = $17527.95

Break Even Point = TCO_{sm}/Annual revenue

= $152591.69 / $17527.95

Break Even Point = 8.71 years

Conclusion

	Dug's immersion cooled system	Supermicro's Air-cooled system
Operating cost	$555.41 per year	$3027.456 per year
Present Worth	$33495.44	$ 791.90
Future Worth	$80718.83	$ 1557.83
Annual Worth	$4007.76	$ 112.75
Internal Rate of Return	11.20%	7.14%
Total Cost of Ownership	$140877.90	$152591.69
Break Even Point	7.04 years	8.71 years

- **Dug's immersion cooled system** not only slashes operating costs but also boasts present, annual, and future value. With a remarkable high IRR, minimal ownership costs, and a swift 7.04-year break-even point, it clearly outshines Supermicro's air-cooled system.