Using Biomimicry and Passive Design to Depend Less on Mechanical Cooling in Humid Places

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Microsoft's data centers are not yet on track on reducing water use and replenishing more water than they consume. But nature has already perfected the solution.

A passive cooling system for data centers that enhances sustainability

The Problem

Data centers consume massive amounts of energy and water for cooling, leading to **high operational costs and environmental impact**.

Traditional cooling systems consume energy and rely on water availability, this is unsustainable in water scarce regions.

High humidity environments present an untapped opportunity for water harvesting, but current technologies fail to utilize it efficiently.

The Solution

A passive cooling system inspired by the **Stenocara beetle,** integrating hydrophobic panels with alternating hydrophilic nodes.

Panels **passively** capture moisture from the air, reducing reliance on external water resources.

Collected water is reused in the cooling system, lowering energy consumption and improving efficiency.

The Impact

Sustainability & cost-effectiveness, making data centers more environmentally friendly and economically viable, while saving more than **100 Million Liters** of water per data center annually, in humid places.

Scalable and adaptable for existing and new data centers, enabling widespread industry adoption.

Supports long-term operational savings while aligning with global sustainability goals, such as water-positive initiatives.

Microsoft’s invested 2.7B in Brazil to enhance their data center infrastructure

In September 2024, Microsoft announced plans to invest **14.7 billion Reais (~$2.7 billion)** over three years to expand cloud computing and AI infrastructure in Brazil’s burgeoning data center market. As of March 2025, with 60 operational data centers and 45 more planned, Brazil is undoubtedly laying the foundation for a robust digital future.

However, this rapid expansion presents challenges. **Brazil’s diverse climate necessitates innovative solutions to manage high humidity and temperature levels.** Furthermore, data centers consume substantial amounts of energy and water to operate effectively, making it imperative to implement measures that protect Brazil’s rich tropical environment.

Addressing these challenges is crucial to solidifying Brazil’s role as a hub for data scalability in Latin America.

60 operational data centers & **45** planned data centers

Microsoft invested **$2.7B** in Brazil to enhance their data center infrastructure.

Problem

A single drop of humidity can creep through microscopic cracks, setting off a domino effect

Moisture can cause short circuits, metal corrosion, and component degradation.

75–95%

average humidity range in Brazil

In Brazil, average humidity ranges from **75%–90%**, significantly higher than the ideal **45%–55%** range for data centers. This gap must be controlled to minimize static electricity risks and prevent condensation on circuits and sensitive equipment. Condensation can cause short circuits, **leading to shutdowns, data loss, and disruptions across entire networks.** Prolonged exposure to high humidity stresses electronic components, increases maintenance needs, and reduces operational efficiency.

Managing humidity also places a heavy load on cooling systems, driving **energy-intensive mechanical cooling** and raising concerns about the sustainability of data center growth in Brazil. For **Brazil's AI infrastructure** to scale sustainably, it must **rely less on mechanical cooling** and prioritize humidity control to ensure operational stability and prevent cascading failures.

Problem

Brazil's AI infrastructure needs to rely less on mechanical air cooling due to large scale water/energy waste

40%

of energy is consumed by cooling systems in data centers.

2L of Water

are evaporated per kWh of cooling in data centers

Mechanical cooling systems, which use fans, compressors, chillers, or pumps to manage heat in data centers, are highly resource-intensive, often **depending on external water sources for processes like evaporative cooling.** Additionally, even when traditional cooling systems reuse water there is a limit because of risk of scale formations.

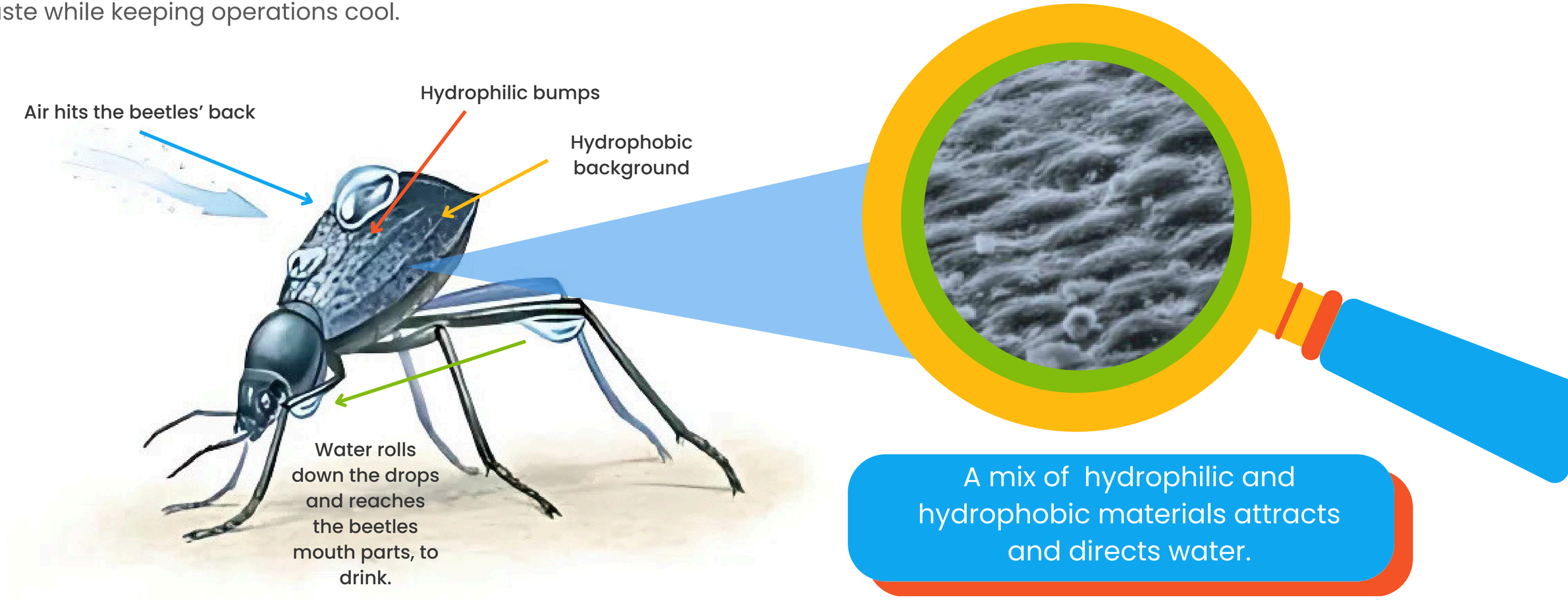
In high-humidity regions like Brazil, these systems become even less efficient, requiring more energy to handle moisture-laden air. This inefficiency leads to **substantial water and energy waste**, higher operational costs, and increased carbon emissions, making mechanical cooling unsustainable for long-term scalability, particularly in water-stressed or energy-sensitive areas.

To encourage and keep the growth of Brazil's AI market, building innovative solutions to control temperature and humidity levels is essential.

A **passive** cooling system for data centers that captures and reuses atmospheric moisture using hydrophobic panels inspired by the Stenocara beetle, reducing both water and energy consumption by minimizing reliance on mechanical cooling.

Inspired by the Stenocara beetle, harnesses moisture to cut water and energy use.

In the scorching deserts of Namibia, the Stenocara beetle survives by pulling water straight from the air. What if Microsoft's data centers could do the same? Our bio-inspired solution turns humidity into a resource, slashing water waste while keeping operations cool.



Inspired by stenocara-beetle we can build panels to collect water with zero energy

Optimize Panel Design for Maximum Water Capture

Refine the hydrophilic-hydrophobic pattern to enhance moisture collection efficiency and ensure effective water drainage for cooling.

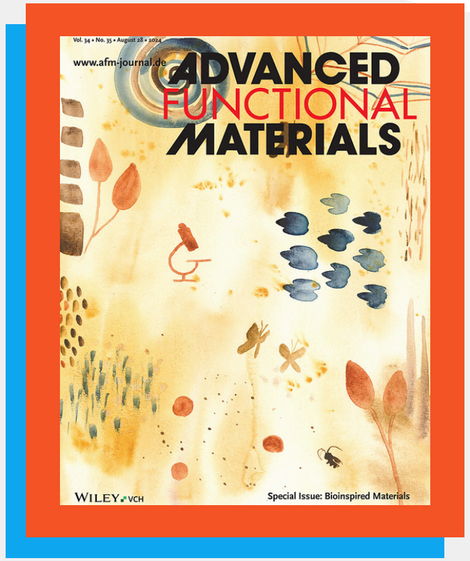
Integrate with Existing Cooling Systems

Develop a seamless method to channel collected water into current data center cooling infrastructure, minimizing energy and water consumption.

Reap the Benefits of Passive Design

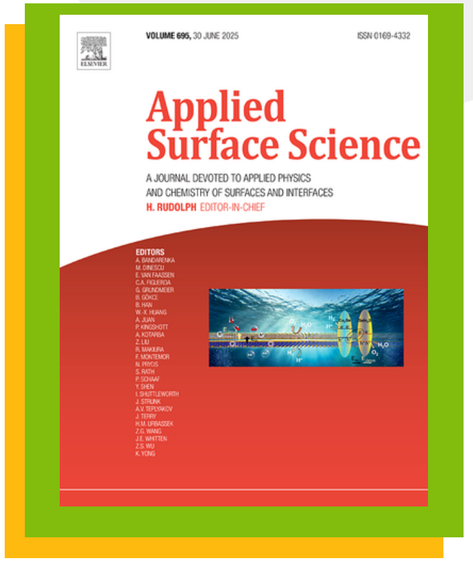
Capture water naturally with a passive system that lowers costs, saves energy, reduces maintenance, and boosts sustainability.

Increasing surface for panel design for large scale water capture via biomimicry

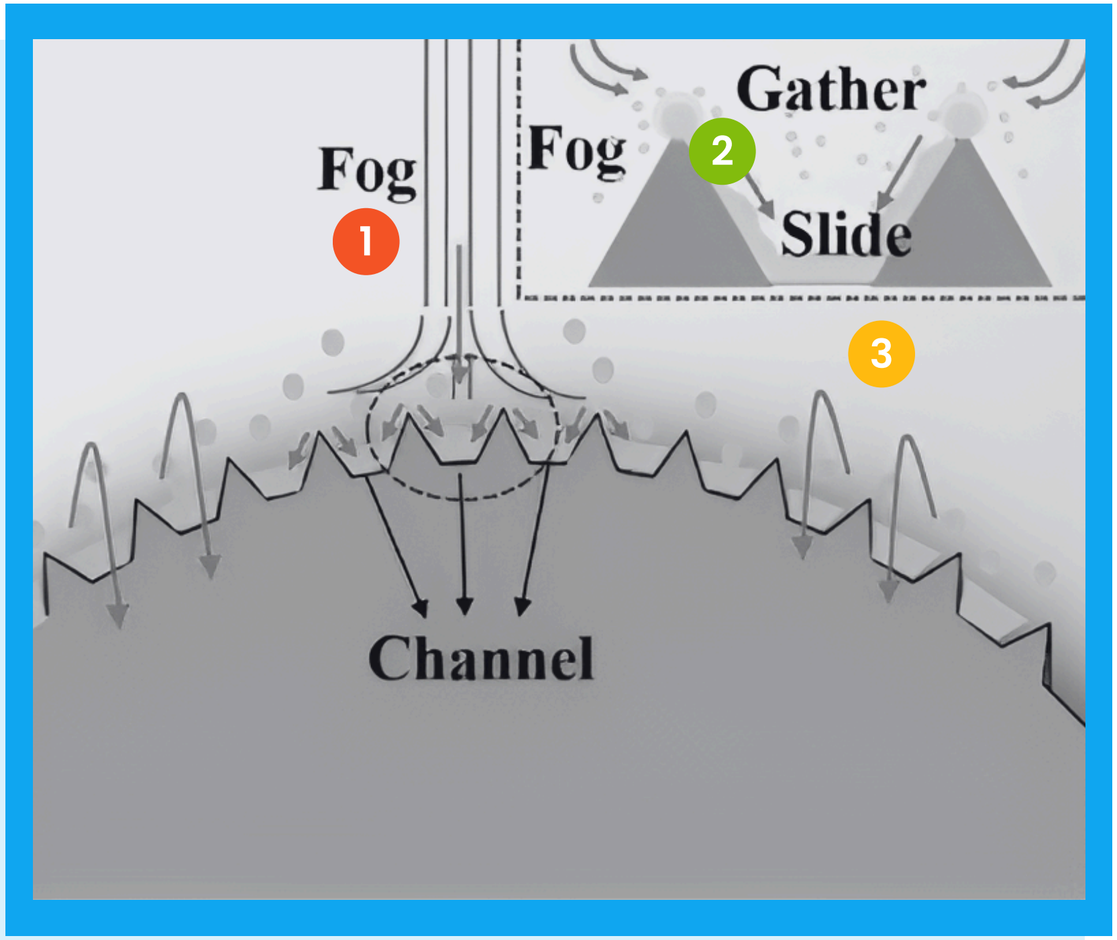


Bioinspired fog harvesting, modeled after nature, has improved efficiency by up to 8x, offering a sustainable large scale water collection solution for data centers in water-scarce and humid regions.

The study validates biomimetic fog-harvesting technology by showing that surface patterns inspired by the Stenocara beetle do not improve water collection efficiency, but influence drop coalescence and motion, aiding optimization for practical use.



Water Droplets Merge and Collect for Cooling, Reducing External Water Use



1

Interception & Deposition
Tiny airborne water droplets (1-40 micrometers) attach to the panel's surface.

2

Coalescence & Growth
Small droplets merge on hydrophilic nodes, forming larger water drops.

3

Drainage & Collection
The collected water is funneled and repurposed for cooling, reducing external water consumption.

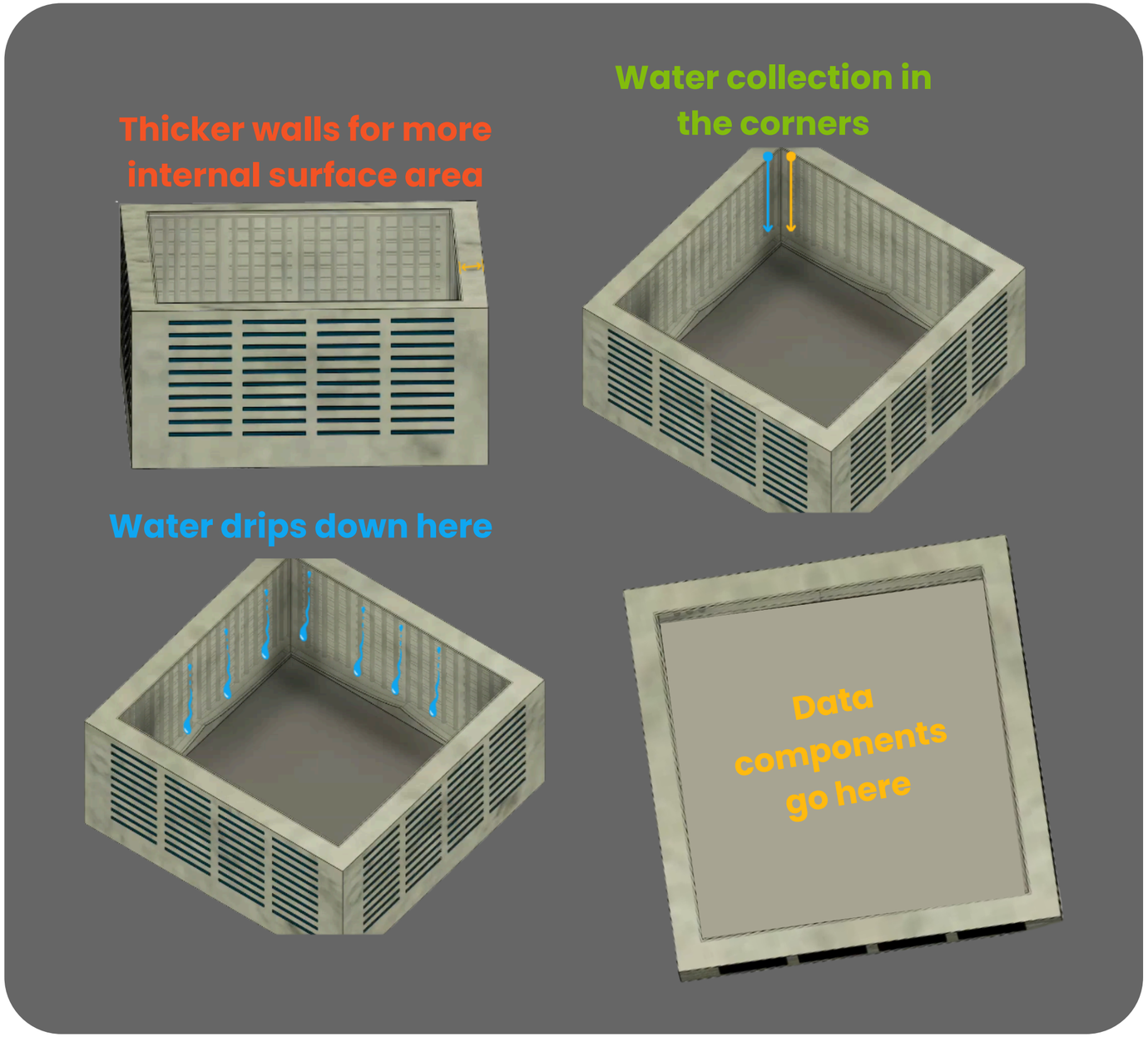
Mimicking the Stenocara Beetle to Protect Data Centers

This is cool! Click it...now

The Video

Also look at this!

The 3D Model



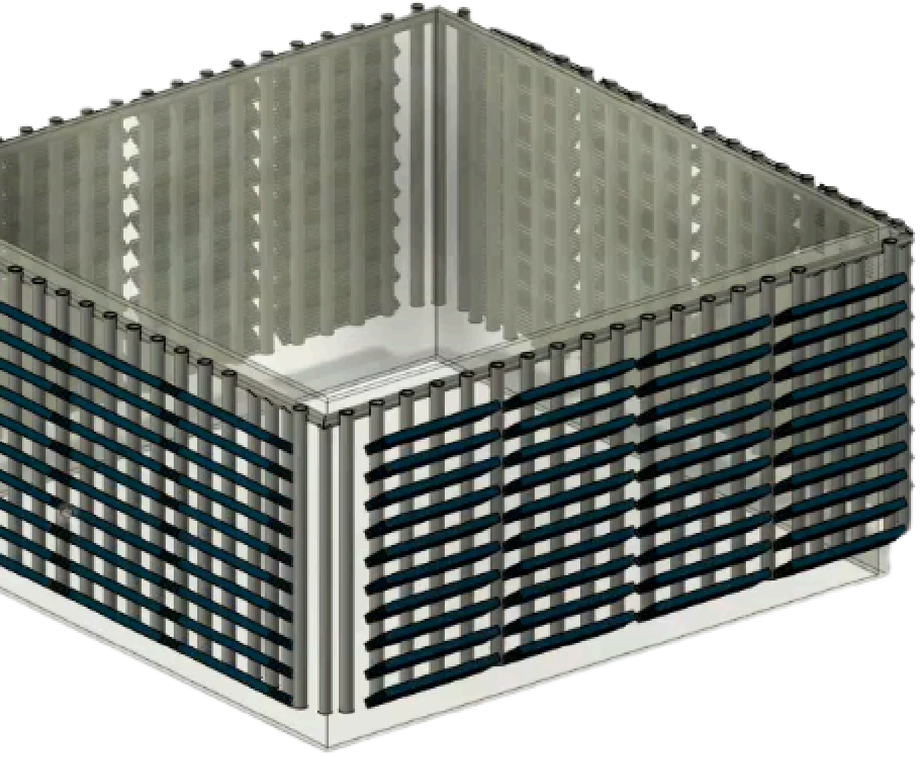
How our Structure Collects and Directs Water

If you haven't clicked it yet, you still can...

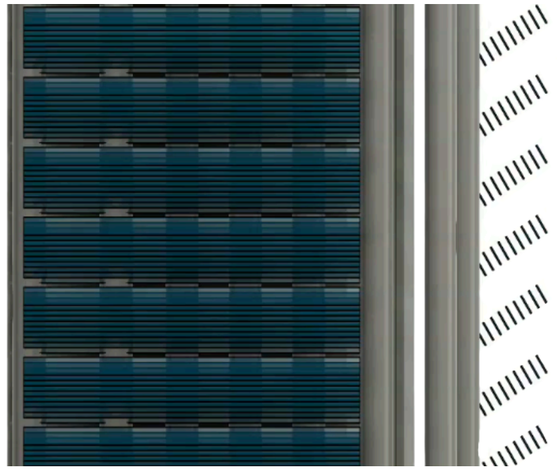
The Video

See it for yourself

The 3D Model



Multiple sub-layers for greater efficiency and surface area



Tilted design increases surface area

Water collected by the mesh flows downward

100M Liters of water saved per year in Microsoft Brazilian Data center

The typical water usage range per data center using mechanical cooling is 960-1175 Million Liters.

By harvesting water from the air with a 10% efficiency rate, we can recover **96–117.5 million liters** per data center, equivalent to 10% of the total water usage, saving approximately **$84K to $100K** each year, based on an average water price of $0.88 per 1,000 liters.

To see calculations click here or see appendix

41M kWh/year saved in energy consumption

Given Microsoft's mechanical cooling WUE of 2.3 - 2.8 L/kWh, our solution is projected to save **41.7M - 41.9M kWh** annually.

Translating to a **$6 million USD** cost reduction per year at an electricity rate of $0.16/kWh.

To see calculations click here or see appendix

Microsoft 2030 is to become environmentally sustainable and meet the market needs

Helps water scarcity

This solution supports Microsoft's 2030 water-positive goal by replenishing more water than it consumes while ensuring data center stability in South America and humid places amid growing droughts and water scarcity.

Massive reduction in water and energy usage

Hyperscale data centers can become carbon neutral by reducing reliance on traditional cooling. Our solution proves a 5% to 18% efficiency, lowering 70% humidity to around 63% and cutting water usage.

Scalability and expansion

This innovation allows Microsoft to expand into humid regions once deemed inefficient while scaling globally to water-stressed areas like the Middle East, Australia, and California, advancing sustainability goals.

Risks include variable water collection efficiency and high initial implementation costs

Variable Atmospheric Humidity & Water Collection Efficiency

The efficiency of water collection depends on relative humidity levels. If ambient air moisture is too low, water collection may be insufficient.

However, key places where Microsoft Brazil's data centers are located, like São Paulo and Rio de Janeiro, are pretty consistent with their humidity levels since they are very tropical and that esentially boosts moisture.

Implementation Costs

While the initial implementation cost for installation may be high, the long-term savings will outweigh the initial investment by far.

Additionally, partnering with local net/mesh suppliers can decrease the material and shipping cost. While also positively impacting the local economy.

Implementation cost

Example Cost for One of Microsoft's Brazilian Data Centers

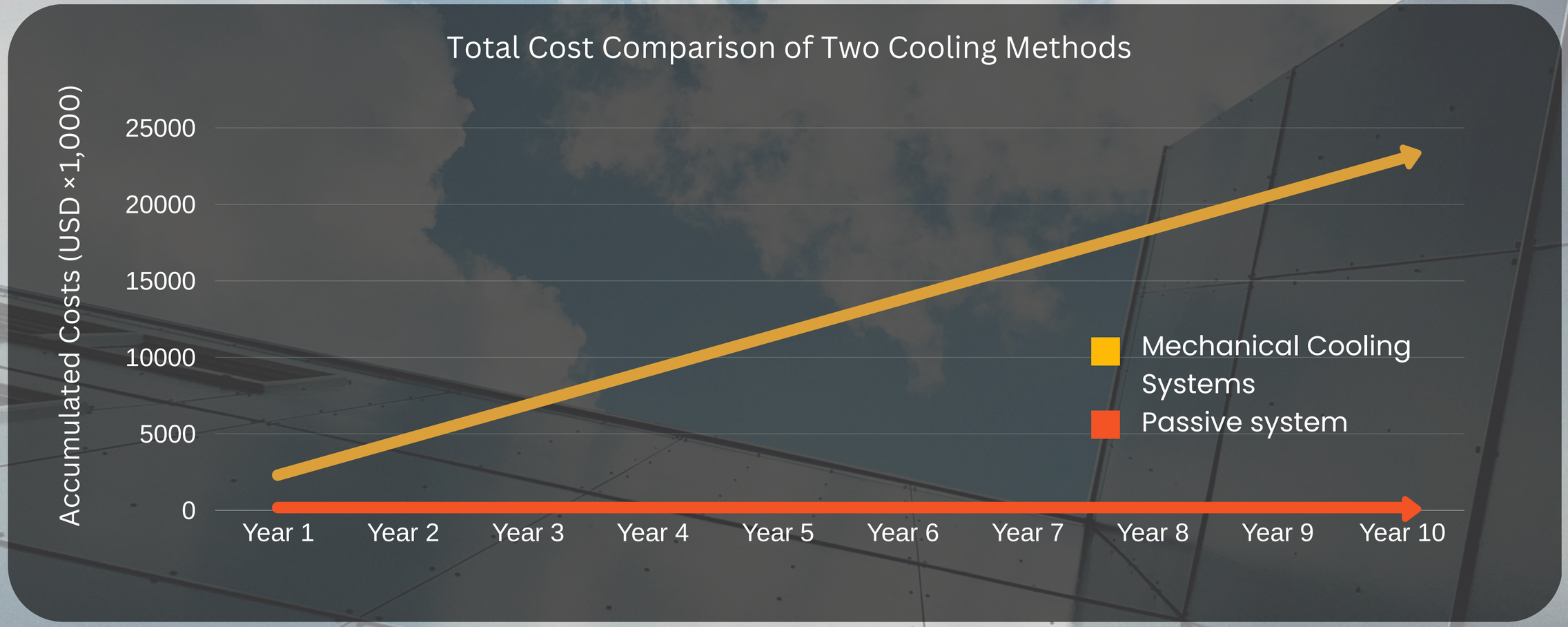
The mesh, typically made from nylon, polyethylene, or polypropylene netting (shade cloth), comes in varying densities to capture different amounts of water.

Based on Google Maps, Microsoft's data center in **Hortolândia, Brazil** has a perimeter of ~1,800 meters. Installing panels 4 meters high around it would require **7,200 m²** of material. At $25–$37/m², the estimated cost for one layer is **$180K.** This covers material only; maintenance is minimal over the panels' **10-year lifespan.**

To see calculations click here or see appendix

Implementation cost

This solution requires a one-time investment that delivers long-term savings.



To see calculations click here or see appendix

Phase 1 - Implementation

Microsoft can test the foundation of the solution in 7 months

Months 1-2

Feasibility & Concept Validation

- Conduct simulations and lab-scale tests to validate the biomimetic panel design (hydrophilic nodes and hydrophobic surfaces).

Months 3-4

Prototype Development

- Fabricate modular prototype panels and integrate them with a small test segment of an existing cooling system.
- Install preliminary monitoring tools to capture performance metrics.

Month 5

Initial Testing & Data Collection

- Run the prototype in a controlled environment to assess moisture capture efficiency and cooling performance.

Phase 2 - Implementation

Microsoft can launch a pilot and scale up in 12 months

Pilot Deployment & Optimization

- Deploy the optimized prototype in a pilot setting within a Microsoft datacenter.
- Refine system parameters based on real-world performance feedback and ensure compatibility with closed-loop water reuse systems.

Months 6-7

Scale-Up & Full Deployment

- Initiate phased retrofitting across selected Microsoft data centers.
- Integrate the system with existing water reuse and cooling infrastructures while
- establishing continuous performance monitoring.

Months 8-12

Monitoring & Scaling Globaly

- Continuously monitor, evaluate, and iterate on the system to further enhance energy efficiency and water conservation, contributing toward Microsoft's sustainability goals.
- If it works in 1 datacenter it can work in other data centers with similar regional characteristics. This phase will be focused on bringing the technology to a globally.

Ongoing

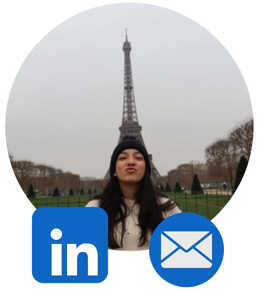
> Your Inspired stenocara beetle biomimicry solution can have a real positive impact. For example, some data centers are located in regions where water is becoming scarce, and this solution could provide them with more. It’s a remarkable breakthrough!

Mathieu Green

Consultant | Entrepreneur at Horizon TI

Malek Hammoud

Technical



Maria Rivas

Problem & Biomimicry

Ayman Oumamass

Cost

Kathya Otero

Impact numbers

Dear Microsoft,

We would like to express our sincere thanks to your team for this wonderful opportunity to help Microsoft achieve its vision: of scaling AI sustainably. As a team passionate about problem-solving, we have learned so much and will be able to apply this knowledge into future projects we take on. This chance to contribute an idea to help Microsoft's sustainability goals was a truly special experience.

The four of us are extremely excited to see the company grow even more. Please contact us with any questions or comments about our recommendation. We hope our proposal inspires further action!

Best regards,
Maria, Malek, Ayman, and Kathya

Appendix

Sources

Calculations