Saving $331.9M Every Year With Passive Cooling

Using Windcatchers to Improve Data Center Cooling

Self-Cooling Architectures

Executive Summary

Problem

Microsoft's current cooling system is not optimal leading to both financial and environmental concerns.

Microsoft's current cooling system depends on substantial energy and water usage.

➜ **Rising energy costs:** Energy demand for cooling data centers as well as rising energy costs constitutes an extra **$800 million of expenses** per year for Microsoft.

➜ **Environmental impact:** Microsoft's current cooling system contributes to high levels of water use.

➜ **Noise Levels:** Current cooling systems have high levels of noise, with an average of **92dB**

Solution

Our recommendation entails redesigning Microsoft's data center infrastructure with passive windcatchers for energy-efficient cooling.

➜ By incorporating tall wind towers and ventilation shafts, we can create a **natural cooling** system that leverages prevailing winds and **temperature differentials** to regulate the internal climate of data centers.

➜ Enhances **airflow** and facilitates **passive cooling**, significantly reducing the reliance on energy intensive cooling systems.

➜ AI and data analytics algorithms will be implemented to **continuously** monitor and **adjust** the cooling infrastructure, ensuring optimal performance and **resource optimization**.

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Impact

An estimated 87% reduction in water usage and 40% reduction in total energy, equating to 4.35 billion litres, 2.24TWh, and $331.9M saved every year.

➜ By using passive air cooling, no water will be needed to cool the facility, drastically decreasing the total water used.

➜ Passive cooling offers the opportunity to eliminate costs related to cooling and therefore, save the energy that would be spent.

➜ Numbers are based on Microsoft's 2022 Sustainability Report.

➜ By using a more energy effective system, Microsoft will be closer to **removing 100%** of the carbon it has emitted since its founding by 2050.

Cooling the Servers

Problem Breakdown

Rising Energy Costs

Most major cloud providers report a **8% to 12%** energy cost increase from 2021 to 2022 with an estimated higher energy price in 2024. Due to this, Microsoft anticipates incurring over **$800 million** in additional energy costs this fiscal year, which is expected to bring down its operating margins.

Environmental impact

Data centers account for **3% of global energy use**. This means that one data center consumes the same energy as **50,000 homes** annually. With Microsoft's **electricity consumption of 12,969,363 MWh** this year, Scope 3 emissions reported an **increase of 23%** year over year, meaning innovative solutions are needed to reach Microsoft's goal of being carbon negative by 2030.

Scalability challenges

Global hyperscale data center capacity is expected to **triple** in the next six years,. Furthermore, the surge in data creation, growing at a rate of over **60% annually** and is expected to increase significantly by 2025, reaching an **average of 15 to 20 kW per rack**.

Data Center Statistics

Energy Consumption and Water Usage

6B

Litres of water Microsoft consumes in data centers

340 TWh

Data center electricity consumption in 2022

$25M

Cost of running a large data center yearly

1T

Amount of IoT messages Microsoft data centers processes

The Status Quo

Current Cooling Methods

Forced Air Cooling

- This is an energy intensive, **forced cooling** method that uses HVAC pumps to circulate air inside the data center. Water-intensive cooling towers are also used to cool the incoming air.

Liquid Cooling

- Liquid cooling is a newer technology that relies on a chilled liquid running over cooling plates on chips. This process still requires **forcibly cooling** the liquid in order to cool the chips.

- Due to a liquid's capacity for more efficient heat transfer, this process is about **40%** more energy efficient than air cooling.

Adiabatic Cooling

- Adiabatic cooling uses thin nozzles to spray low amounts of **water** onto **incoming air**. The water will take the heat and evaporate into the outside air. In its place, the now cold air will enter a low energy pump to enter the data center.

- This process is about **90%** more efficient than air cooling but still uses water and energy

Our approach to the problem

Optimizing Passive Cooling

1

Using Passive Cooling

The major drawbacks of cooling are the massive water and energy use. A solution to this is **passive cooling**. This is the process that takes advantage of environmental factors such as **prevailing winds and thermal properties** to cool data centers. With no energy being used, it conserves the amount of power used for cooling while also **removing** the need for water.

2

Optimizing Cooling Systems

AI offers many chances for **data center optimization**. In this case, we can use AI to optimize the passive cooling system in order to maximize the heat transfer. Using **thermal imaging** techniques and **airflow modelling,** we can successfully optimize the way our passive cooler should be built. This will allow for the **most efficient** systems, saving more water and energy

Solution Requirements

What Does Microsoft Need

Profitability

- With a history of consistent revenue growth, Microsoft aims to maintain this trend and potentially surpass the **$211 billion mark** in the coming years.

- Microsoft plans to spend more than **$50 billion per year** on cloud infrastructure, with estimates saying that Microsoft will spend more than **$30 billion** on data centers in 2024.

Zero-Emissions

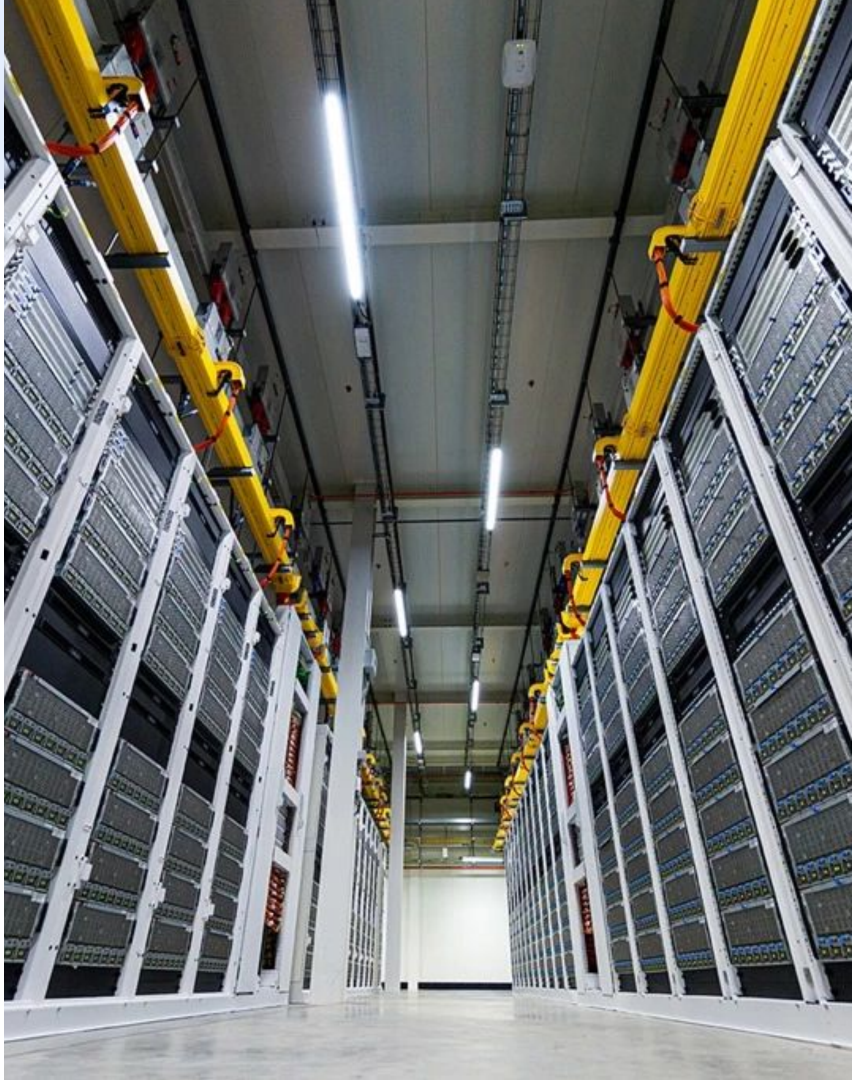
- In 2050, Microsoft aims to remove from the environment **all the carbon the company has emitted,** either directly or by electricity consumption, since its founding in 1975.

- In 2030, Microsoft aims to remove more carbon from the environment than it emits.

Reduced Noise

- Research has shown that the average noise level around server areas in data centers can reach up to **92 dB**, with noise levels within server racks potentially reaching **96 dB**.

- Complaints regarding noise from data centers are a significant concern for data centers as well as residents living near these facilities.



Why Passive Cooling?

Energy Consumption Comparison

48MWh

Forced Air Cooling

28.8MWh

Liquid Cooling

4.8MWh

Adiabatic Cooling

0 MWh

Passive Cooling

Energy statistics are calculated per year, per data center

Seeking Domain-Specific Validation

What experts have to say

Amirreza Shoara

Sr. Data Center Development Engineer, AMD

Felipe Maximiano

Data Center Infrastructure Manager, eStruxture Data Centers

> Your emphasis on passivity in your solution is a significant advantage, particularly in environments where energy usage is limited or expensive.

> Given that we're in a country where we can benefit from outside weather, the solutions proposed there aren't used normally in data centers, I've only heard of a couple that used something like that before. Which makes it very unique.

#1 | Feature

Windcatcher Cooling System

Cooling represents 40% of the energy used in a data center, almost equalling the energy used by the actual servers.

Windcatchers utilize prevailing wind currents to cool the inside of the building. Using this strategy, we can effectively create a passive air-cooling system that will be cooled with the wind current. It's implementation can be used to reduce energy cost and water use.

This is possible for two reasons:

- **Materials**: Windcatchers primarily use clay as their building material. Compared to concrete, this material has a much lower heat capacity, meaning it will take in less heat from its surroundings.

- **Architecture**: Air flows from the top of the windcatcher and flows into the building. Thermal buoyancy kicks in and hot air is circulated out of the building, replaced by the cooled air coming in.

Click here to check out our design of the windcatcher cooling system in a data center!

Click here to learn more →

Architecture Breakdown

Mapping out

The Cooling Journey With Windcatchers

1 → 2 → 3 → 4

Heating

Chips will release heat as they are used for energy-intensive tasks, causing the chips to warm up. This will **heat** the air inside the data center.

Exchange

The thermal properties of air will force hot air to rise and be **expelled** through the windcatcher while cold air will be brought **into** the data center due to negative pressure differentials.

Cooling

As the **cool air** is brought to the data center, **heat transfer** will occur between the hot chips and cool air. The chips will be cooled as heat is transferred to the cool air and the process repeats.

Optimizing

Optimization of the windcatcher will happen through **modelling** airflow and heat properties. Based on the predictions, adjustments can be made to the structure.

#2 | Feature

Thermal Optimizer

"How can windcatcher cooling be optimized for the best outcomes?"

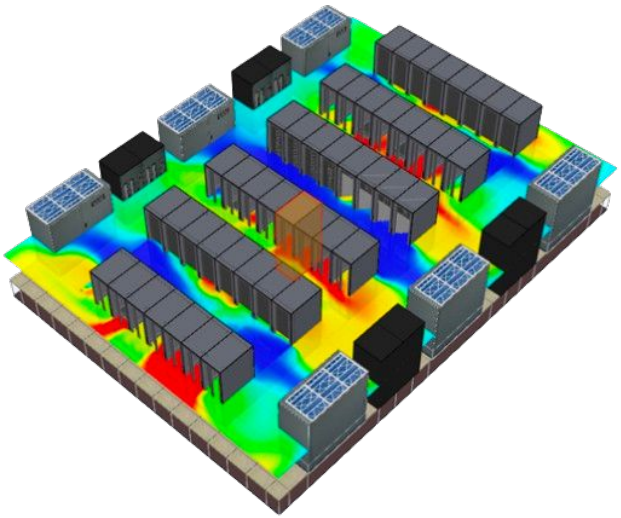
The challenge with building self-cooling structures is knowing how to **build** the structure to **remove as much heat** from the air coming in while also being able to get rid of hot air. Without proper **heat transfer** in the windcatcher, the data center will not be cooled properly, leading to potential damage.

To make sure this can happen, we will use a thermal optimizer model to **predict heat patterns** and airflow in the windcatcher. Using the suggestions from the model, a design for the windcatcher can be reached that will meet the goals we want.

An optimizer will make heat transfer occur when the air is coldest and release hot air efficiently.

Recent advancements in Computational Fluid Dynamics (CFD) models will help us solve this optimization problem. By having more cool air, servers will be able to run more smoothly, thus saving energy.

Optimizing for the Best Cooling in Data Centers



Click here to learn more →

Technology Breakdown

Advantages Over Air Cooling

Reduced Noise

With passive cooling, there is **less noise** emitted from the data center. The outcome of this is easier **data center expansion** and development as people living nearby will **not be disturbed** by the noise of the cooling system.

Cost Efficiency

With passive cooling and architecture optimization, Microsoft is able to achieve significant **water and energy savings**. These gains will lead to less money being spent on these data centers, while also reaching Microsoft's projected **sustainability goals**.

Water Savings

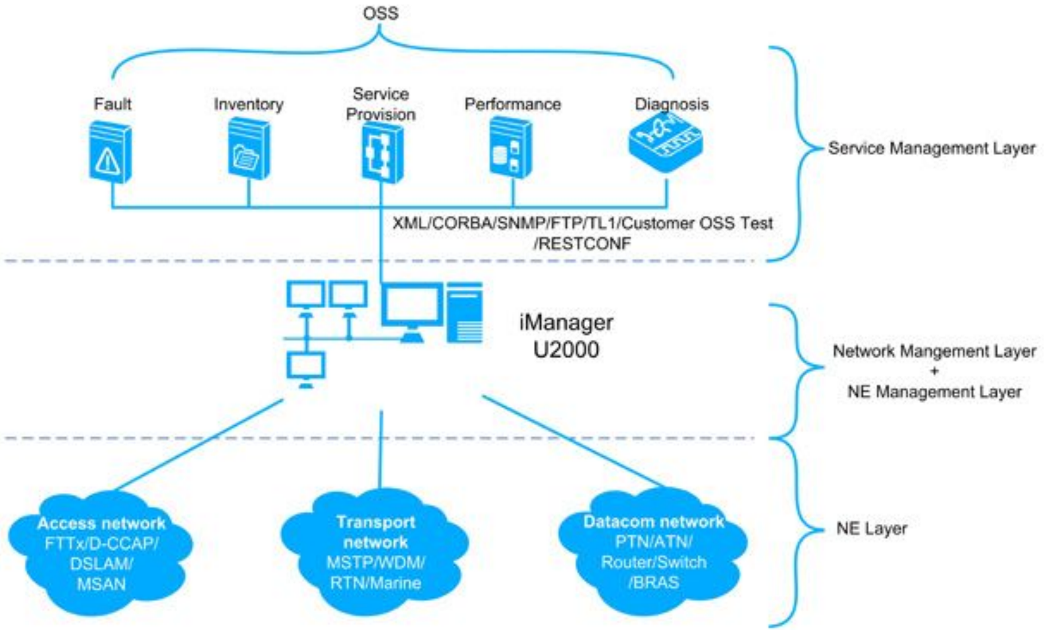
With passive cooling, there is no need for water as the air is **automatically cooled**. This differs from forced air cooling where air has to be **forcibly** cooled in a cooling tower, wasting **significant amounts of water.**

Huawei - Case Study

Huawei was able to improve the resource utilization rate of its facilities by 20 percent with their optimization tool

Huawei created a simple AI monitoring tool to detect fault location algorithm and data center power utilization monitoring.

After its release, Huawei was able to improve operational quality and efficiency while reducing costs by 35%.



Click here to learn more → Case Studies

The Plan

Implementation

Phase 1: Planning and Research (~5 weeks)

Microsoft should first **validate** the proposed idea. While a lot of thought has gone into this idea, it is still good to confirm this with more **architects and engineers.**

Phase 2: Development (~10 weeks)

Blueprints need to be created for the windcatcher by architects. While this is happening, the **CFD model** can be **trained** for its application to the windcatcher.

Phase 3: Pilot (~20 weeks)

To **pilot** this idea, we need to build a small scale model. Our idea is to build this in an **Indonesian datacenter**, using the hot and humid environment to test the windcatcher **integrity.**

Phase 4: Global Implementation

Assuming the pilot is successful and the windcatchers are optimized, fully passive cooled data centers can be built across Europe and Asia first, before moving to the heavily optimized American data centers.

Phase 5: Maintenance and Updates

Microsoft needs to maintain the windcatchers. As the structure is important, maintenance is necessary for proper cooling. The datacenter should also be monitored, making sure it is being cooled correctly.

Click here to learn more → Implementation Plan

Steps to Success

What we need from Microsoft

In order for our recommendation to be successful, we need Microsoft to allocate sufficient resources and systematically deploy them.

Model Development

Allocating a budget of $400,000 towards the **CFD model** and its development is crucial to **success** as the budget will be used to develop the model. This money will cover the cost of **training** the models as well as paying the **engineers** working on it.

Windcatcher Construction

There are **several components** for implementing the windcatchers in data centers. These costs include: building materials, labour, maintenance, and others. In total, this should come out to around **$400,000** per data center. However, with energy and water savings, these costs can be easily regained.

Click here to learn more → Financial Plan

Gaps and Assumptions

Mitigating Risks

Mitigating risks is a big part of an architectural solution. While we have done research into the mechanics of our recommendation, there are some things that can be done to reduce risk even further.

Model Validation

Validating the CFD model is **important** as improper results can have negative **consequences**, possibly reversing the benefits of passive cooling. To validate the model, **pilot projects** should be run at data centers before fully implementing them everywhere. By doing this, Microsoft will be able to adjust factors if necessary and determine whether the model is working **properly**.

Proper Maintenance and Updates

Considering the importance of **proper airflow** in passive cooling systems, it is **necessary** that the windcatchers are properly **maintained**. This can be achieved through annual checkups and cleaning. Also, in places that **experience snow**, it is important that it is cleared to maintain the **integrity** of the windcatcher's structure.

Opening into the Opportunities

The Impact Of Our Recommendations

4.35 Billion Litres of Water Saved Per Year

With an estimated **87% reduction** in water usage in data centers, Microsoft will save **4.35 billion litres**. This number is sure to rise as server use increases. (Microsoft Sustainability Report 2022)

60 Megawatts of Power Saved Per Year

Assuming that data centers are about **30%** of Microsoft's energy consumption, and **40%** of that energy goes towards cooling, our solution will save **2.24 TWh** per year. (Microsoft Sustainability Report 2022)

$331.9 Million Dollars Saved Per Year

With estimate costs of **$0.0043 per litre of water**, and about **$140 per MWh**, Microsoft will be able to save **$313.2M in energy costs** and **$18.7M in water costs**, for a total of **$331.9M saved** per year.

Our recommendations will empower Microsoft to save hundreds of millions of dollars by using passive cooling.

Dear Microsoft, with immeasurable appreciation,

THANK YOU

David Shan

Jerry Yao

Divyan Bavan

Nico To

Through this challenge, each of us has grown immensely. From learning how to assess the future of data center technology, reaching out to industry experts, delving deep into Microsoft's vision and crafting a recommendation deck, this incredible journey has been one of great growth and learnings.

We are beyond grateful to have been given this opportunity, thank you!

Thank You Video

All the little details you may need

Playbooks

What is the technology behind our system?

Technology Breakdown

How does passive cooling work?

Architecture Breakdown

What are other companies doing similar concepts?

Case Studies

What does implementation look like?

Implementation Plan

What are the budget projections?

Financial Plan