RBC Global Asset Management

Semiconductors – the water challenge

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Key takeaways

- Water is an essential input to the semiconductor ("semi") manufacturing process, which takes place on a significant scale across Asia.
- Semis are a vital component in the development of Artificial Intelligence ("AI"), and demand is expected to continue to increase.
- The high concentration of semi fabrication facilities in areas of water scarcity poses considerable internal and external risks.
- Semiconductor manufacturers must explore approaches to water use that protect local stakeholder communities and ensure a reliable supply chain.

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The environmental costs of technology

The rapid expansion of AI across the globe has intensified focus on its environmental impact, particularly the substantial resource demands for water and energy. While the discourse surrounding the environmental impact of AI is mainly around its data centres, semis are a critical component of AI infrastructure and supply chains. As semis are essential for AI operations, their water footprint can be considered an indirect environmental cost associated with AI's production and deployment.

Both AI data centres and semi manufacturing facilities require significant amounts of water. While data centres use water primarily for cooling purposes, semi production is much more water-intensive, requiring significant volumes at nearly every stage of the process. Taiwan's largest chip manufacturers consume 12% of the country's total industrial water supply[1], illustrating the industry's deep reliance on water resources. As the global competition for AI leadership accelerates and demand for semis rises, sustainable solutions will need to be found for industrial water management.

This growing demand for semis is now driving major policy initiatives, with governments recognising the strategic importance of both AI and the infrastructure required to support it. In January 2025, Trump announced the Stargate Project, a USD500 billion private-public partnership aimed at expanding AI infrastructure within the U.S.[2]. On the other side of the world, China has long been a leader in supporting its domestic semi industry, reinforced by its "Made in China" 2025 plan, which includes a goal of 70% self-sufficiency in semi production by 2025[3].

[1] JPMorgan, September 2024.
[2] scientificamerican.com/article/heres-whats-in-stargate-the-usd500-billion-trump-endorsed-plan-to-power-u-s/.
[3] JPMorgan, September 2024.

In fact, the semi industry has become a key focal point in the U.S.-China rivalry, with both countries leveraging industrial policies such as export restrictions and domestic subsidies to advance their competitive positions.

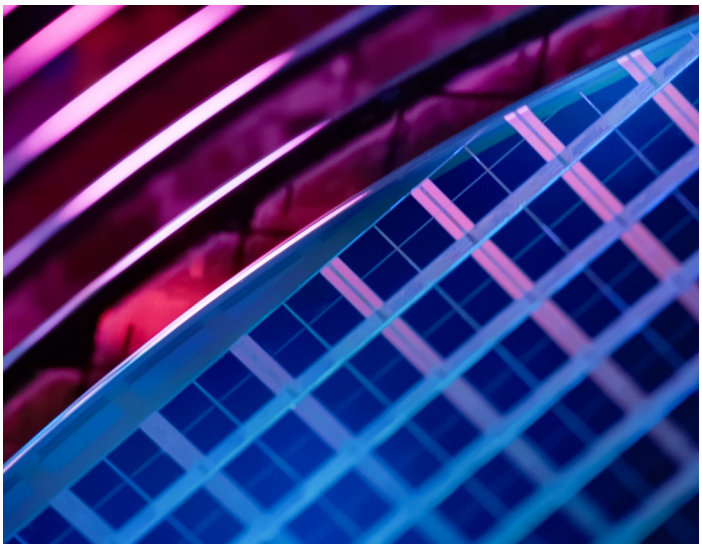
The water challenge for semi manufacturing

As more countries look to onshore semi manufacturing and expand production capacity, the semi production process – including its critical reliance on water – will come under more intense scrutiny. Water availability is increasingly becoming a key factor in semi manufacturing, for as capacity increases, so does the demand for water resources, making it a growing concern for long-term sustainability of the industry.

Compounding the issue is the fact that there are many regions globally that are currently facing water scarcity, designated as 'water stress' areas. This term refers to areas where the demand for water exceeds the available supply, or where water resources are severely limited. Today, many existing semi production sites – particularly in China – are in high water stress areas. China currently operates 44 semi fabrication plants, with an additional 23 under construction and 10 more planned[4]. However, based on data from the World Resources Institute, more than half of these will be in areas of water stress, with 43% in areas of "extremely high" water stress. In these regions, the future of the industry is heavily reliant upon the development of scalable water resources.

However, such projects require significant financial investment. Expenditure for new semi production facilities can be up to USD20 billion depending on the size of the facility[5]. Of this total, approximately up to 10% is typically allocated to water-related projects, including the installation of ultrapure water ("UPW") and wastewater treatment systems. When presented with spend figures such as these, it becomes evident that water is one of the most important elements in the semi production process.

The strict cleanliness requirements for producing semis are well known even outside of the industry. Images of sterile 'cleanrooms' – highly controlled environments designed to minimise contaminants – illustrate the intricate nature of the production process. To ensure optimal performance, wafers (the foundation for producing integrated circuits and microchips) must be free of contaminants that could negatively impact their circuits. Because of this, nearly every stage of the fabrication process involves several cycles of washing and rinsing with UPW.



Water is used in several different ways throughout the production process, with approximately 75% used in the manufacturing process itself[6]. The remaining amount is consumed by cooling towers and scrubbers, which are used to remove contaminants. Notably, the development of UPW requires copious amounts of water. As a result, both the chip manufacturing process and the water purification process contribute to the industry's significant overall water demand.

Potential solutions to water scarcity

Given that demand for both semis and water is expected to grow, innovative solutions are emerging to expand the water supply.

Water recycling is a method of water re-use that can be applied at various stages of the fabrication process, although the intricacy of semi fabrication can make implementation difficult.

Use of reclaimed water is also a method of potentially extending the useful life of water. Wastewater can be treated and recycled from both households and larger water-intensive facilities, appealing to cost-sensitive investors due to reductions in both wastewater output and required input through the use of a recycled commodity.

Finally, desalination technologies can offer viable pathways to mitigate scarcity and support the industry's long-term sustainability. The number of desalination plants has been growing globally, but production and cost efficiencies must be improved for the technology to become properly scalable.

[4] JPMorgan, September 2024.
[5] construction-physics.com/p/how-to-build-a-20-billion-semiconductor.
[6] JPMorgan, November 2024.

Importance of Asia and Asian companies

Corporations and governments across Asia play a critical role in creating sustainable growth in semis and data centres. Three of the top five largest semi manufacturing countries in the world – Japan, China, and Taiwan – are based in Asia. Because of their established position in the semi industry, Asian institutions are increasing their involvement in the global search for water resources.

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As an example, in 2021, Singapore launched the Sustainable Tropical Data Centre Testbed ("STDCT"), the first tropical data centre testbed. This is a joint venture between Nanyang Technological University Singapore, National University of Singapore, and 22 industry partners, government agencies, and research institutions, all working together to drive innovation and sustainability. The technology partners contribute cutting-edge solutions for testing and validation, while industry leaders offer insights into market needs and operational challenges.

According to STDCT, its projects aim to help data centres reduce energy consumption and carbon dioxide emissions by up to 40%, decrease water usage by 30-40%, and achieve a power usage effectiveness of less than 1.2 for a combination of air and liquid cooling. By developing innovative cooling technologies for use in tropical climates, the STDCT has the potential to set industry standards while enhancing Singapore's competitiveness within the industry.

Our approach

For bottom-up active managers such as ourselves, the demand for more water use in the semi production process creates compelling long-term opportunities to add exposure not only to semi producers and manufacturers, but also to companies involved in treating water for industrial use. From the creation of UPW, to recycled and desalinated water, there are various ways to capture the upside as the industry scales up to meet future demand.

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Chris is a portfolio manager on the RBC Asian Equity team at RBC Global Asset Management (Asia) Limited. He is the team's financials and real estate specialist. Prior to joining the organization in 2015, Chris was a sell-side equity analyst at Bank of America, where he specialized in the financials sector across Asia. He had earlier worked at HSBC in a number of sales and risk management roles in different parts of the world. Chris started his career in the investment industry in 2012. Chris holds an MBA from the London Business School and a Bachelor's degree in Business Administration from Georgetown University. Chris is also a CFA® Charterholder.

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