The physical footprint of AI: Is your semiconductor fab ready for the revolution?

A guide to building and operating an agile facility

JLL SEE A BRIGHTER WAY

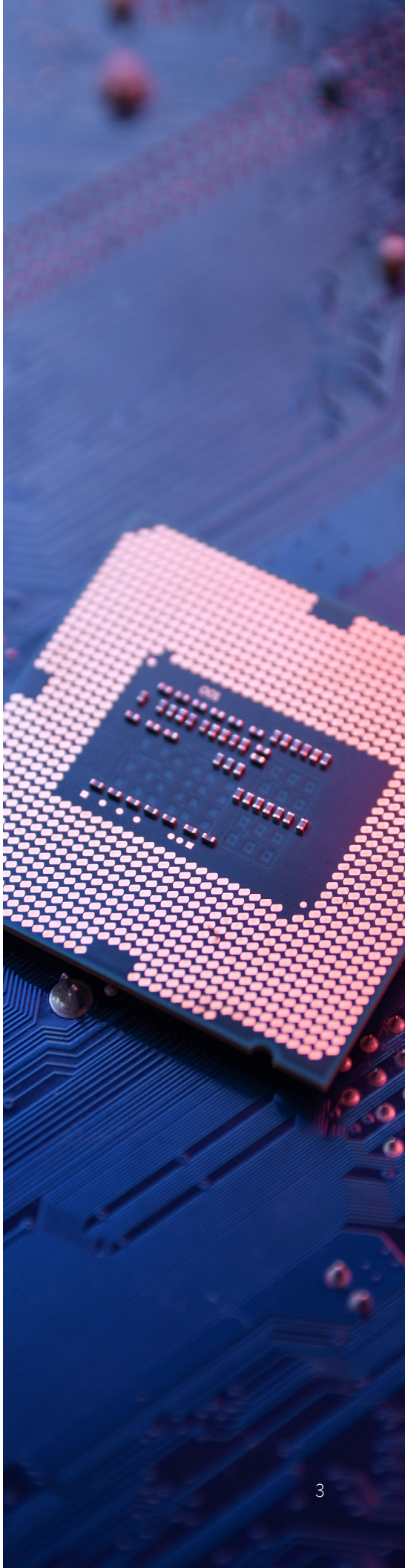
jll.com

Semiconductor fabs push the boundaries of physics to deliver ever more advanced chips for today's enterprises. As AI adoption and innovation fuel demand for chips, semiconductor companies around the globe need smart and scalable real estate strategies to enable cutting-edge manufacturing under increasingly extreme operating conditions.

The unprecedented surge in demand for semiconductors, driven by the AI revolution, is fundamentally reshaping the industry. This is not merely a production challenge; it is a real estate and facilities crisis. The AI boom has elevated the physical fabrication plant, or "fab," from a passive container into a critical, active instrument of manufacturing. For Corporate Real Estate (CRE) leaders within the semiconductor industry, the facility is no longer just a cost of doing business–it is a strategic enabler of production, innovation, and market leadership.

This new reality creates a cascade of operational complexities that push modern fabs to their engineering limits. The demand for more powerful chips, fueled by a generative AI market projected to expand at a 41.5% CAGR through 2030, places immense pressure on the physical asset. Success now depends on how well senior leaders can master the real estate challenges tied directly to their core responsibilities.

This guide offers a strategic framework and insights for building and operating a semiconductor fab that can meet the demands of the AI era, turning facility performance into your most critical competitive advantage.



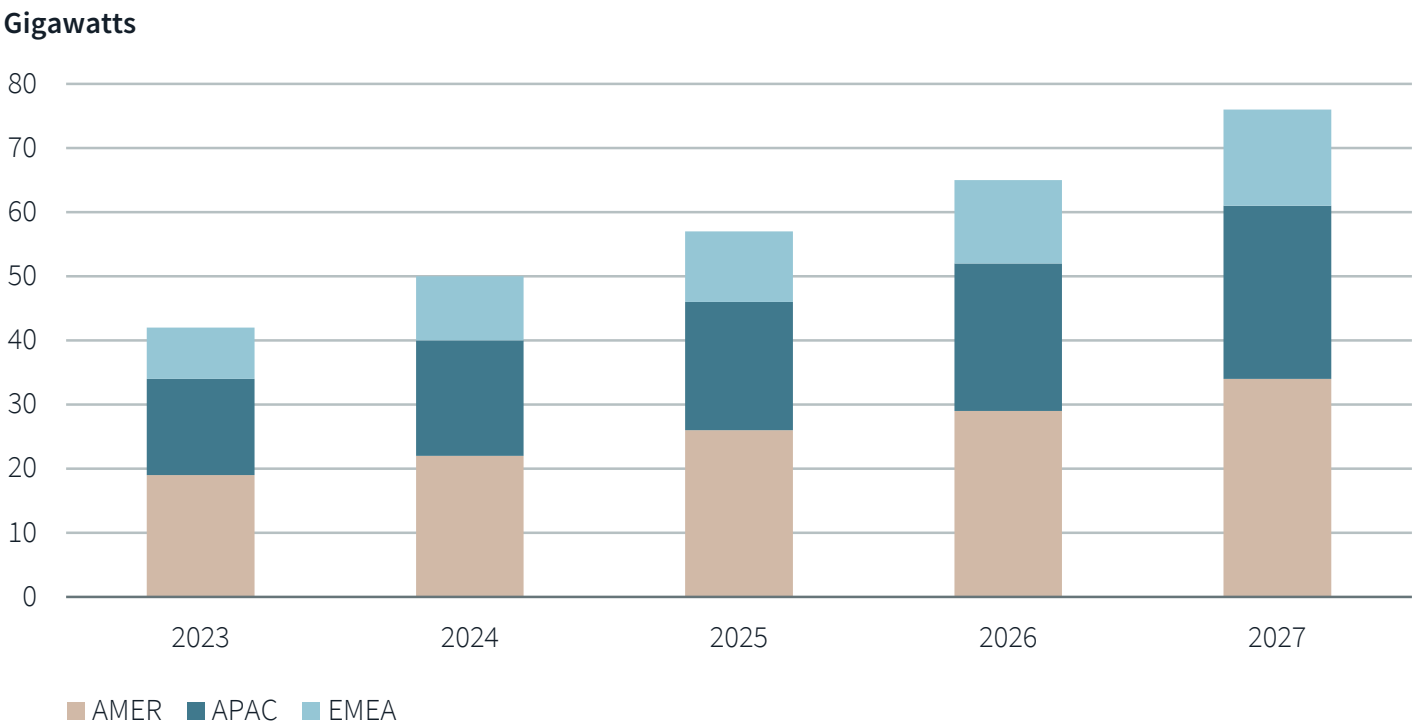
00

Getting oriented: Supercharged demand, more complexity

The demand for AI is fueling an exponential surge in data center capacity and the need for advanced computing power, directly increasing production quotas and straining existing fab capacity. According to JLL research, the global data center market is likely to expand at a 15% CAGR or higher through 2027, based on developments currently under construction and planned.

Global data center capacity projected to grow at 15% per year but this will not be sufficient to meet growing demand

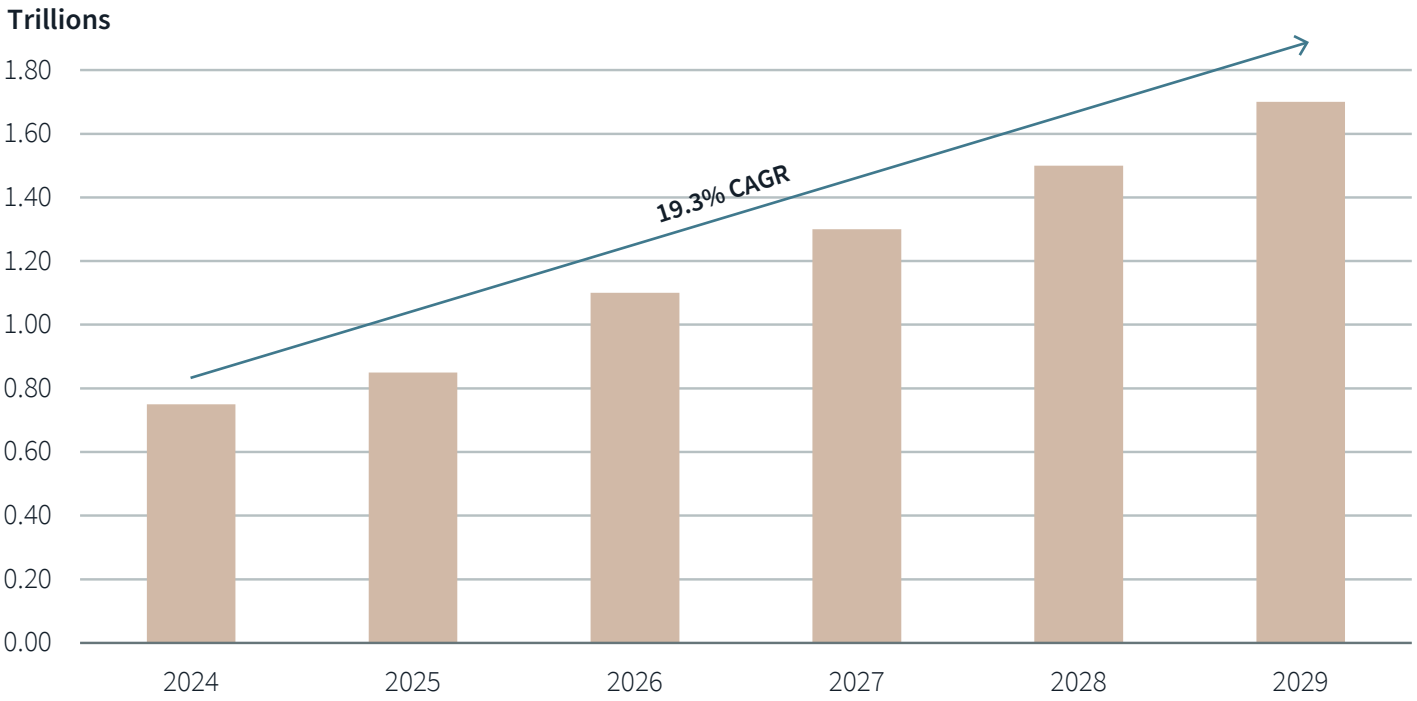
Data center capacity (gigawatts) 2023-2027



Source: JLL Research, 2024, Structure Research
Note: Capacity includes hyperscale and colocation

Leading AI applications rely on specialized IT infrastructure, including graphics Processing Units (GPUs) that are used to train and deploy generative AI models. AI also requires a mix of other semiconductors, from CPUs to memory chips. The global cloud market is seeing rapid expansion not only from AI demand but also from digital transformation, as organizations move towards cloud-based computing for greater agility and cost savings. Global Cloud spending is expected to more than double in the next five years, according to data from BMI.

Global cloud spending



Source: BMI 2025

AI is not only propelling demand for the silicon wafers that serve as the foundation of semiconductor material – it's also revolutionizing chip design. The industry is using AI and machine learning tools to create chips with optimized power, performance and area (PPA) while automating repetitive tasks such as chip layout optimization, which can significantly speed up design timeliness and reduce costs. Advances in chip packaging and the rise of chiplet technology further improve time to market.

As AI helps design more complex chips at a faster pace, CRE leaders must plan for underlying labs and production facilities that are more agile and adaptable. These facilities must feature infrastructure capable of handling rapid changes in tooling, environmental requirements, and process flows – such as next-generation machines that are larger and more resource-intensive. Having the right facilities for advanced chip production is critical to maintaining your competitive edge, and that starts with choosing an optimal site.

01

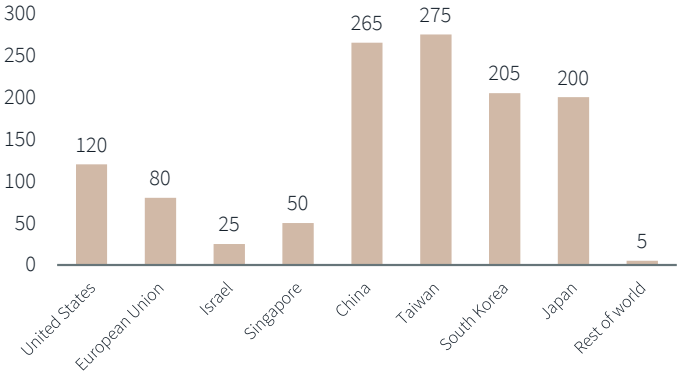
Site selection: Location factors

Finding and securing the right site is the foundation for successfully expanding your semiconductor manufacturing footprint. A wide range of factors inform the site selection process for a chip fab, including utilities and infrastructure, availability of skilled labor, government incentives, and even seismic risk.

Fab sites must meet specific requirements for stable power supply and water resources in order to operate. Water is essential to clean and rinse the semiconductor devices at various steps and is also used in cooling systems to maintain the manufacturing equipment at optimal operating temperatures. An average fab can use up to 10 million gallons of ultrapure water each day to rinse and clean wafers. In addition, large chip fabs can consume up to 100 megawatt hours of energy per hour, the equivalent of more than 80,000 North American homes, according to McKinsey & Company.

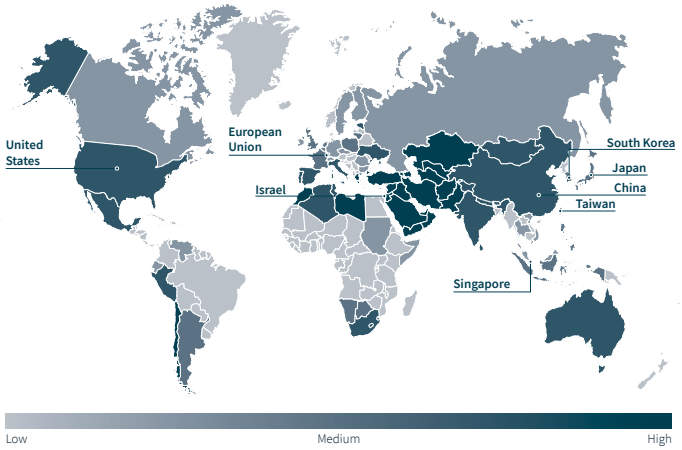
Annual water withdrawals of semiconductor manufacturing by country/region (2021) and water stress by country (2030)

Annual water withdrawals of semiconductor manufacturing in million cubic meters (Kearney analysis)



Sources: WRI; Kearney analysis

Water stress 2030 in business-as-usual scenario (WRI Aqueduct)

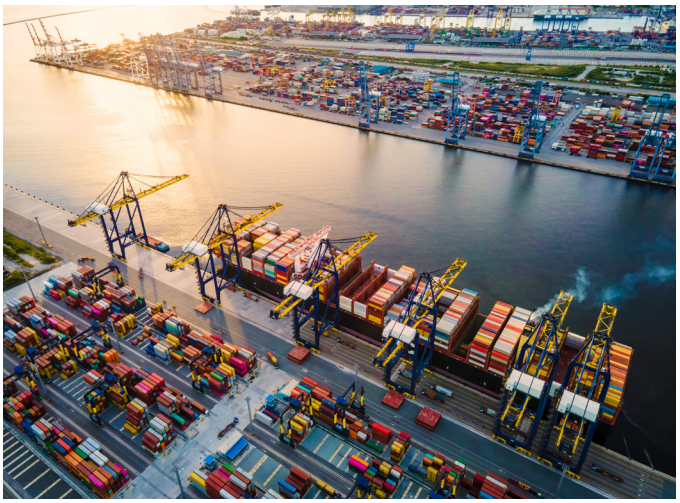


Sources: WRI; Kearney analysis

> “
>
> New plants are built at the best suitable sites with access to optimum supply chain capabilities and ideal infrastructure of the highest energy efficiency. Existing plants, on the other hand, have to adapt and change quickly because of technologies emerging every three to five years.
>
> **Philip Goh** →
> *Executive Director, SEMI Practice Lead, Asia-Pacific, JLL*

Proximity to skilled labor is another important factor in site selection – including both construction labor to build the fab and a sustainable workforce of engineers and technicians to staff it once wafer production starts. Many chipmakers have partnered with trade schools and four-year institutions to develop a talent pipeline for their facilities.

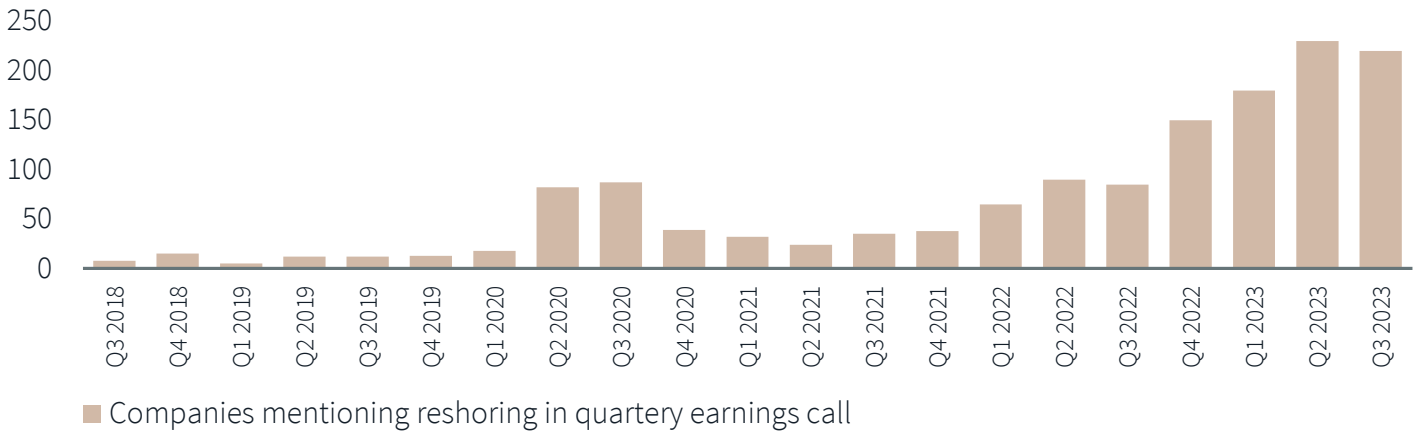
Adding another variable to siting decisions, governments around the world have ramped up support for domestic chipmaking activities through incentives such as grants, loans, tax credits, and workforce training rebates. In addition to national-level incentives, smaller localities also may offer incentives and tax abatements based on job creation. The availability of national, state, and local government incentives to help defray capital outlays can play a significant role in your fab location decisions. Partnering with an expert can help you understand the full landscape and how to balance incentives with other cost factors, such as the cost of labor and construction.



Supply chain vulnerabilities brought to light during the pandemic and trade tensions between the U.S. and China have played an increasing role in location decisions in the semiconductor industry, giving rise to de-risking strategies and increased regionalization. Many companies are rapidly diversifying their supply chains and adding manufacturing facilities closer to their end-users to mitigate risks in a rapidly changing landscape that includes the potential for increased tariffs and sanctions.

Spotlight: North America

The frequency of companies exploring the options of relocating manufacturing operations to the U.S. is increasing



Source: JLL Research

02

Construction management: Rising to the challenge

Building state-of-the-art semiconductor fabs demands meticulous planning and adherence to strict budgets, timelines and quality benchmarks. Robust strategizing and execution are all the more vital in the face of serious global headwinds, including construction labor shortages, strained supply chains, regulatory hurdles and material price volatility.

Building a modern fab represents a monumental capital investment. Industry analysis shows that costs for a leading-edge facility can often exceed $10 billion, a massive budget divided between the physical facility and the advanced manufacturing equipment. Bringing a project of this scale to life requires a workforce of 6,000 to 8,000 workers and a multi-year timeline, often taking two to three years from groundbreaking to the start of production.

While these are overall estimates, your construction timeline can vary dramatically depending on the location. For example, fabs typically take twice as long to build and incur double the cost in the U.S. compared to Taiwan, according to a report by Semiconductor Digest. Permitting speed, construction, and labor practices, and the quality of supply chain and industrial expertise are all reasons for this divergence.

For CRE leaders, the task of getting a new fab online is an exercise in extreme project management. These leaders must orchestrate a multitude of contractors and integrate specialized vendors for everything from cleanroom walls to gas delivery systems and wafer-handling robotics. The success of a multi-billion-dollar project rests on their ability to manage this complex choreography on time and on budget.

In the race to supply the world's chip demand, superior speed-to-market can be a game changer for manufacturers. Many semiconductor makers accordingly seek to build fabs and start operations as quickly as possible, despite the massive complexity and scale of these projects. A specialized construction management team can mitigate risks and ensure safety and quality in the entire process from base build through tool installation, even on a tight schedule.

For a global semiconductor manufacturer's new greenfield assembly and test, JLL is serving as the Project Management Consultant. The project involves a 1.2 million square foot facility with 500,000 square feet of clean room area. JLL's scope includes managing site progress, quality, safety, and project costs. The project has become a benchmark that is helping to shape future regulatory standards for semiconductor manufacturing in the country.

Country:	India
Size:	1,300,000 sq ft
Scope of services:	Project Management

Results:

Enabled superior efficiency and performance throughout the build

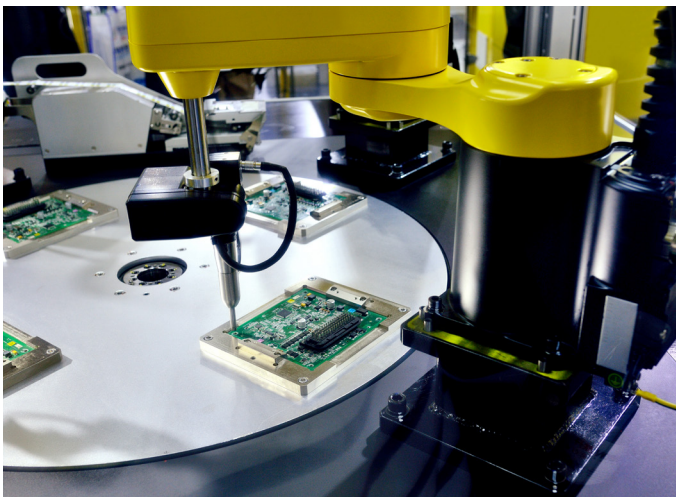
03

Facilities management: Unlocking higher performance

Semiconductor fabs run 24/7 to manufacture objects with atomic-level precision. Spanning up to 1 million square feet or more, today's chip factories require sophisticated property and facilities management to ensure operational efficiency, maximum uptime and compliance with environmental regulations. CRE leaders on the front lines are under immense pressure to meet these demands.

The production of leading-edge chips for AI requires unique manufacturing environments with even stricter tolerances for contamination, vibration, and power stability. These chips are produced in clean rooms where particle contamination as well as temperature and humidity are controlled more tightly than ever. Clean rooms for 3-nanometer semiconductor processes require "zero dust" ISO Class 1 environments, meaning there are no more than 10 particles per cubic meter at sizes of 0.1 microns or larger.

Cutting-edge machines also impose extreme operational requirements on fabs. An example is the adoption of ultraviolet (EUV) lithography, which uses high-powered lasers to pack 50 billion transistors onto a single fingernail-sized chip. Not only are EUV lithography machines huge and energy-intensive, but they also require high-purity hydrogen, extreme vacuum environments, and frequent maintenance, posing unique challenges for fab infrastructure and operations.



In a modern fab, where every minute of unscheduled downtime on a critical tool can represent millions of dollars in lost production, maximizing uptime is paramount. While unplanned downtime costs the broader industrial manufacturing sector an estimated $50 billion annually, the financial stakes in a 24/7 semiconductor facility are exponentially higher. This intense pressure demands a fundamental shift from reactive repairs to sophisticated predictive maintenance for all facility systems to ensure efficiency and protect output.

Smart facilities management is essential for successfully operating a fab and protecting yields under increasingly challenging conditions. Integrating processes, technology and data across teams – both inside and outside the production environment – can unlock efficiencies at a time of labor shortages and rising costs. Investing in digital tools can streamline your processes and enable better decision-making.

For instance, FM teams must engage in the lengthy process of suiting up every time they enter a clean room. The use of proximity sensors to alert the team when service is needed allows them to enter less frequently, saving time. Digital platforms can drive efficiency by integrating the vast amount of data generated by your fab operations. JLL Serve is an end-to-end digital FM application that uses AI to pull data from connected and non-connected assets into one interface, enhancing operational effectiveness, compliance and cost management.

A Fortune 100 semiconductor firm faced aging infrastructure and inefficient operations across 80+ U.S. sites. JLL implemented an integrated facilities management (IFM) partnership using proptech and mobile engineering services. This strategic approach cut supply costs by 20%, minimized disruptions, and improved asset life cycle planning, rebooting the client's operations for greater efficiency and cost control.

Country:	United States
Size:	5M sq ft
Scope of services:	Integrated Facility Management

Results:

75% reduction in response times for maintenance requests

90% improvement in data accuracy for asset monitoring

50% decrease in unplanned downtime through predictive maintenance

04

Workplace strategy: Attracting scarce talent

Globally, a widening talent availability gap makes recruitment and retention a key challenge for all segments in the semiconductor value chain. The U.S. semiconductor sector is projected to have between 60,000 and 100,000 unfilled jobs by 2030, according to the National Science Foundation. Asia faces a similar shortfall, with Japan projected to see a talent gap of 43,000 engineers by 2030 and South Korea bracing for a 56,000-engineer shortage by 2031.

As the demand and competition for skilled workers intensifies, chipmakers need to invest in creating a healthy and appealing work environment. A focus on aligning your workspaces with your business goals, including designing inspiring work environments that can foster innovation and collaboration, can help you attract and retain scarce talent.

> The semiconductor industry stands at the forefront of innovation, yet many of its manufacturing facilities lag behind in their office and amenity spaces.
>
> **John Leddy** →
> *Managing Director, Technology*

Technology manufacturers tend to focus on the labs and clean rooms where production occurs, but frontline workers (those who interact directly with products) also need well-designed amenity spaces such as cafeterias, break rooms, and lockers. Collaborative spaces and meeting rooms where employees can exchange knowledge are also important. Robust health and safety protocols are essential in manufacturing, but features such as natural light, quiet zones, and access to outdoor spaces can enhance employee wellness.

Designing an appealing physical environment that emphasizes workers' health and well-being can improve community building and overall workforce satisfaction. Dedicated training spaces within or near manufacturing facilities can also support efforts to upskill frontline workers. A thoughtfully designed workspace can become a competitive advantage for you in the battle to recruit and retain talent and ensure operational excellence.

05

Energy management and sustainability: A smaller ecological footprint

Semiconductors are critical components in renewable energy technologies, from EVs to smart electric grids. Ironically, however, semiconductor manufacturing is highly resource-intensive, consuming copious amounts of electricity and water as well as numerous materials and process gases. Manufacturing of more advanced chips requires more complex processes, which drives up this consumption further.

The semiconductor industry's energy consumption is massive and growing, making it a significant contributor to greenhouse gas emissions. According to a study by the European think tank Interface, energy use by major chip manufacturers more than doubled in eight years, reaching 131,278 GWh in 2023–more than Norway's total electricity consumption in 2022. Due to a heavy reliance on fossil fuels, Greenpeace projects the industry will generate 86 million metric tons of carbon dioxide equivalent by 2030.

The AI boom, with its intensified demands on tech infrastructure and manufacturing, has heightened the urgency of sustainability concerns. The semiconductor industry has also come under increased scrutiny for its environmental, social, and governance (ESG) practices, including from governments with net-zero targets.

> Semiconductor companies have the responsibility to achieve their corporate ESG targets, while complying with government legislation and keeping business operating expenses low.
>
> **Philip Goh** →
> *Executive Director, SEMI Practice Lead, Asia-Pacific, JLL*

Under these pressures, the semiconductor industry has implemented measures to curb emissions intensity during manufacturing, with some success. JLL data shows that initiatives to maximize energy efficiency in day-to-day facility operations can reduce utility consumption by up to 30%.

Energy efficiency measures require the right infrastructure, such as pipes and flow switches, which are easier to incorporate into new construction than to retrofit into an existing facility. An ESG audit of a facility can identify areas for improvement – for example, by installing efficient lighting solutions or upgrading chillers and exhaust fans.

Digital technology solutions such as AI, in concert with smart sensors that gather information on capacity, volume, and other operational data, can also help you maintain a facility at optimum energy efficiency. These and similar features can also help your facility achieve sustainability certifications, such as LEED and BREEAM, which are increasingly valued by the industry.

A smart real estate strategy for the AI era

Advances in AI are placing unprecedented stress on the semiconductor industry. Navigating these challenges–from extreme operational complexity and talent scarcity to massive utility demands–requires a strategic partner with proven expertise. JLL offers an integrated suite of services designed to turn your real estate and facility challenges into a competitive advantage.

From challenge to advantage: Partner with JLL

For unmatched operational excellence and uptime

We deliver resilience where it matters most. Our expertise in **Critical Environment Management (CEM)** and predictive maintenance is powered by a global team of over **4,000 engineering specialists** and advanced technologies like thermal scanning. Globally, we manage over 500 semiconductor environments and more than 250 primary data centers, ensuring maximum uptime and yield protection.

For driving efficiency and sustainability

We turn massive utility consumption into measurable savings. By integrating IoT sensors with building management systems, we help clients **reduce energy consumption by 10-20%**. Our track record includes achieving over **$4M in client energy savings** and securing more than **1,000 sustainable building certificates** in the last five years. Our experts conduct sustainability audits to identify and implement cost-reduction measures, helping you meet your corporate ESG targets.

For navigating complexity at scale

We orchestrate large-scale projects, from concept to successful completion. JLL globally manages **4.8 billion square feet of space and $89 billion in assets**. Our project management teams orchestrate everything from site selection and long-term leasing to the construction of 1,000,000+ sq ft facilities. Our experience across **8,000+ completed transactions** ensures your project is delivered on time and on budget.

For mitigating risk and ensuring compliance

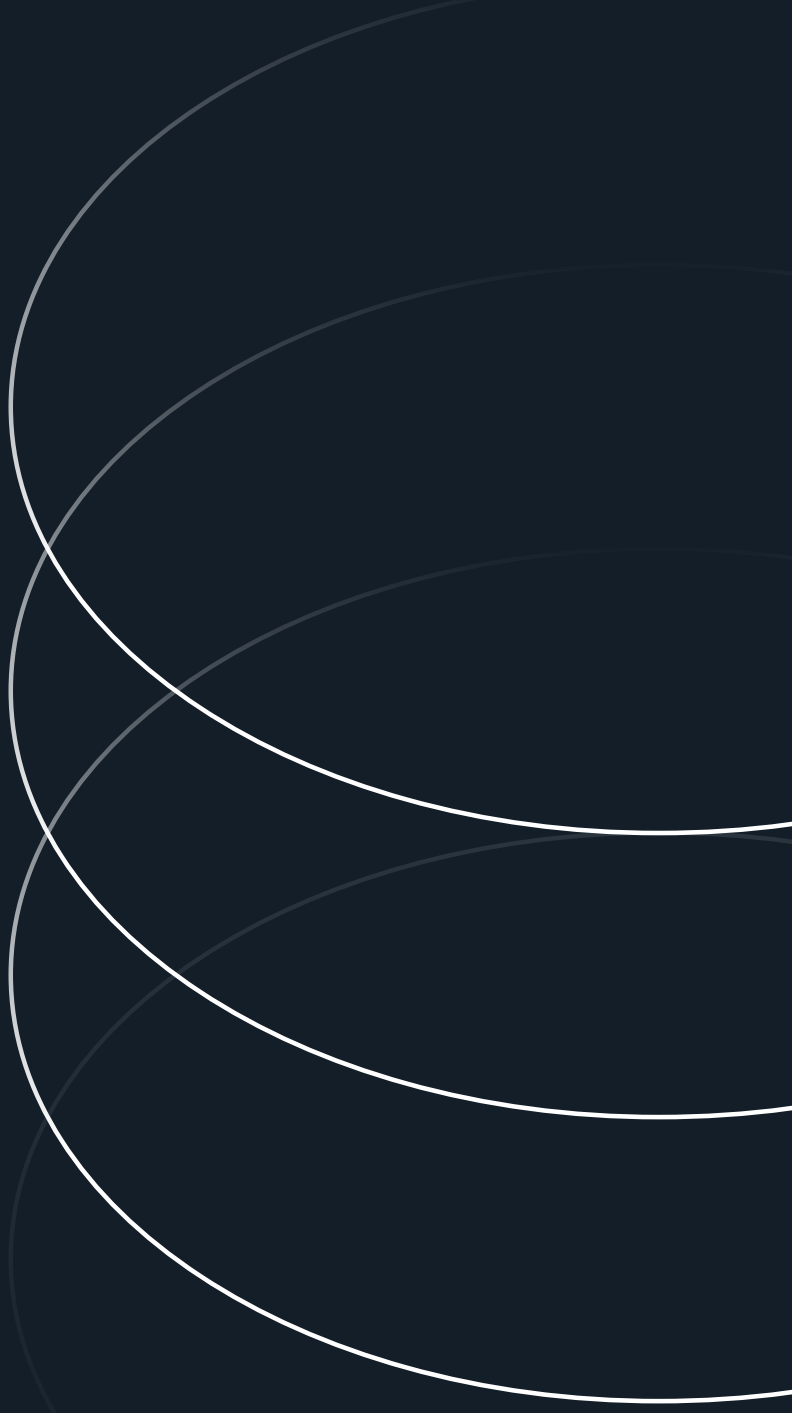
We build a framework for safety and certainty. JLL's proprietary **Compliance Assurance Program (JCAP)** provides a robust system for auditing and risk management. Our EHS management systems, permit to work protocols, and regular safety inspections are designed to protect your people and your assets, ensuring you meet and exceed regulatory standards.

A trusted partner for a demanding industry

Our commitment to excellence is recognized across the globe. As an **Ethisphere World's Most Ethical Company** for 17 consecutive years, a Fortune 500 company, and an **ENERGY STAR Partner of the Year**, JLL is the trusted partner for leaders shaping the future.

Get in touch with our semiconductor practice experts to help assess your requirements and align your operational strategy with tomorrow's production demands.

Connect with JLL →



About JLL

For over 200 years, JLL (NYSE: JLL), a leading global commercial real estate and investment management company, has helped clients buy, build, occupy, manage and invest in a variety of commercial, industrial, hotel, residential and retail properties. A Fortune 500® company with annual revenue of $23.4 billion and operations in over 80 countries around the world, our more than 112,000 employees bring the power of a global platform combined with local expertise. Driven by our purpose to shape the future of real estate for a better world, we help our clients, people and communities SEE A BRIGHTER WAY℠. JLL is the brand name,and a registered trademark, of Jones Lang LaSalle Incorporated. For further information, visit jll.com.