SHINE™

# The Semiconductor Playbook for Fusion



## Executive Summary

The semiconductor industry grew from a half-billion-dollar government niche in 1960 to a trillion-dollar global ecosystem by following a cost curve that reduced the cost of compute by over a trillion times. It did this by following a simple pattern: build machines that make chips, sell chips to paying customers, use the revenue and operating experience to build better machines, and repeat. No single breakthrough drove the cost curve. Commercialization drove it through continuous toil and innovation.

Fusion is already following the same pattern. SHINE's core thesis is that fusion is scaling—and will continue to scale—the way semiconductors did: through staged commercialization across progressively larger markets, supported at each step by real revenue rather than by technical milestones alone. But fusion has one structural advantage the chip industry lacked: the demand already exists throughout the cost curve. The implication—the fusion market could scale faster than semiconductors.

## The Structural Parallel

### Similar toolkit, same scaling dynamics

Semiconductors and fusion are not the same technology. But they draw from a similar toolkit—control of materials at increasingly fine scale results in more efficient systems. One of the key drivers for semiconductors was moving to higher frequency light; for fusion the variables are temperature, density and confinement. Each technology has improved through steady engineering improvements compounding across many subsystems, and not a single breakthrough. For semiconductors, this process has improved the cost of compute by over a trillion times over many decades, and fusion is following a similar curve. For both technologies, the innovation pipeline is far from exhausted.

### Two deep innovation pipelines

The semiconductor cost curve was driven by a long sequence of engineering advances: discrete transistors to integrated circuits, visible-light lithography to extreme ultraviolet, simple processes to computationally optimized manufacturing. Each generation made the next possible.

Fusion has its own pipeline, already producing results. Early commercial systems using hot particle beams and solid (cold) targets are in the field. Higher power systems using plasma targets are now being deployed commercially with better efficiency. Further improvements to target temperature and confinement will enable next-generation applications. Each step forward in efficiency comes at the cost of technical complexity, just as improvements to lithography did for semiconductors.

But it's not just a projection—commercial fusion system cost efficiency is already following that of semiconductors:

*Commercial fusion system cost efficiency is already following that of semiconductors — not as a projection, but as a demonstrated result.*

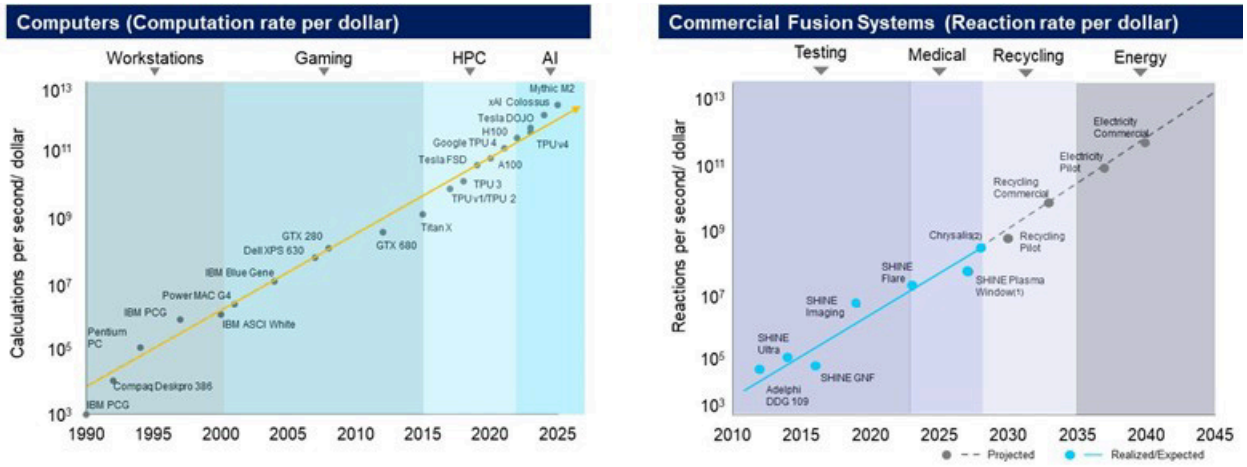



*Figure 1: Semiconductor and fusion scaling curves on matched log scales. Both industries show exponential improvement in output per dollar, progressing through successively larger markets. (1) and (2) reflect SHINE's expected systems (Plasma Window 2026, Chrysalis 2028).*

### No fundamental ceiling

The ultimate cost of both semiconductors and fusion is not limited by raw materials—a critical characteristic that has allowed exponential scaling to continue unabated. Fusion's fuel, derived from the most abundant materials in the universe (light elements) is effectively unlimited. Therefore, the improvement runway remains exceptionally long. This point has significant implications for the potential of fusion relative to other forms of energy: the cost curve probably won't stop at commercial viability—it should continue to improve, driving down the cost of energy and massively increasing access.

*The semiconductor industry had to wait for each market to be invented. Fusion's markets already exist.*

## Two Industries, Similar Market Ladder

Both semiconductors and fusion climb through progressively larger markets as they improve efficiency, each funded by the learning and earnings from the one before it. But there's a difference: the semiconductor industry had to wait for each market to be invented. Fusion's markets already exist.

| Stage | Semiconductors | Fusion (SHINE) | Key Drivers |
|---|---|---|---|
| Early Adopter | Defense and military electronics | Defense and industrial testing | Early government support; niche, but high unit value. |
| Growth | Calculators and industrial equipment | Medical radioisotopes | Calculators replaced mechanical tools; isotope demand already large with insufficient supply |
| Scale up | Personal computers | Spent fuel recycling | PC market didn't exist yet; huge underserved market for spent fuel |
| Transformative | Smartphones, internet, AI | Grid-scale fusion energy | No historical market; underserved, multi-trillion-dollar energy market |

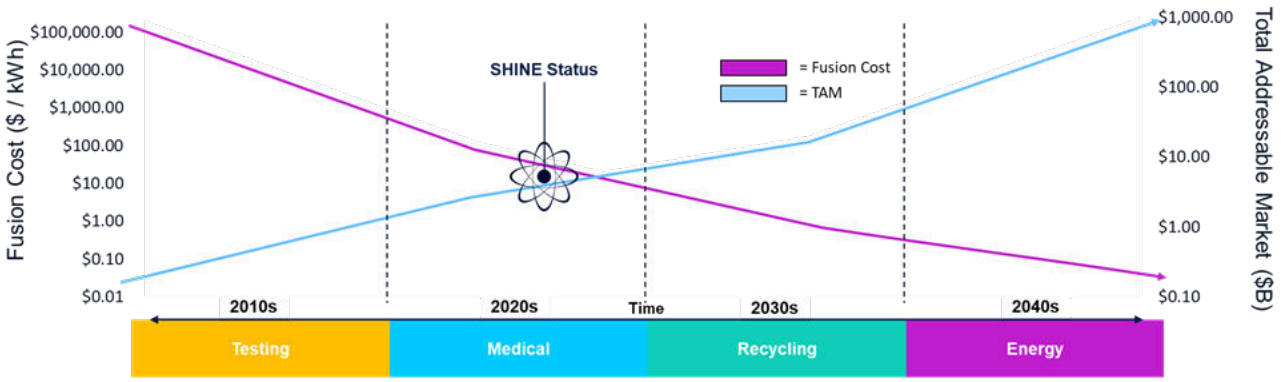



*Figure 2: Approximate fusion cost per kWh equivalent (descending) vs. total addressable market (ascending) on logarithmic scales. Fusion has already reached economic viability for medical uses.*

Semiconductors had to wait for the personal computer to be invented. Nobody in 1960 could have predicted the smartphone. Each new market appeared only after the cost curve made it possible. Fusion's markets—test, medical, recycling, and energy—are already underserved. The demand is visible today and growing across each product.

## Commercialization as Mechanism

The fusion community has historically measured progress by laboratory benchmarks—energy gain, confinement time, temperature records. These demonstrate physics progress, but don't solve the economic problem. A better metric might be cost per kWh.

Commercialization and scale up is limited by the ruthless optimization of economics and competition. When deploying disruptive technologies with the potential to change the world, it's usually best to start with the highest paying customers so you can embed these values into product development naturally. For fusion, it's much easier to make money in the niche markets of test and medicine where it's already commercially viable. Profits here are already helping to fund the next generation of commercial fusion products.

This is the mechanism that has driven some of the most impactful innovations in human history. Recent examples include semiconductors, but also solar panels, batteries, and EVs.

Waiting for a fusion energy machine before deploying commercial fusion systems to earlier markets might be like trying to build the iPhone before the PC or the Tesla Model 3 before the Roadster.

## Key Risks and Mitigants

Materials durability, radiation damage, tritium fuel handling, and capital intensity are genuine constraints. The supply chain that semiconductors built over decades, with hyper-specialized companies optimizing every layer, does not yet exist for fusion. But it didn't for semiconductors in 1960 either. Both paths to building it were and will be full of challenges. Staged commercialization is the primary mitigant. It creates learning loops and economic sustainability long before a grid-scale power plant needs to work perfectly. The question is not whether fusion is hard, but whether the difficulty is better overcome by a virtuous cycle of commercialization or a moon shot.

*The cost of semiconductors was not limited by raw materials. Neither is fusion — and that means the improvement runway is exceptionally long.*



## Beyond Commercial Viability: Energy Abundance

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## Summary

The pattern is proven for hard-tech systems like chips, EVs, solar panels, space launch and more: build machines. Deploy them. Learn. Improve. Repeat. The chip industry followed this cycle from a half-billion-dollar government niche to a trillion-dollar ecosystem that reshaped civilization. Fusion is following the same cycle, drawing from a similar toolkit, compounding through the same dynamics—with the advantage of a market that does not need to be invented. It is waiting to be served.



## Author Bio

Greg Piefer is the founder and CEO of SHINE Technologies, a company transforming nuclear fusion from scientific ambition into real-world impact. Under his leadership, SHINE has developed and deployed commercial, fusion-based systems across sectors including healthcare, advanced manufacturing, and national security—laying the groundwork for economically viable fusion energy. His vision extends to nuclear waste recycling and ultimately developing economically viable fusion energy.

Greg holds a PhD in nuclear engineering and BS degrees in physics and electrical and computer engineering from the University of Wisconsin–Madison.