Build them like machines

DR. IR. ANA KOLLER & JONATHAN JANSSEN

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Starforge exists for one reason: to take fusion from the lab to the factory floor. Here's how we'll do it.

The world needs far more firm, clean power, for electrification, industry and AI. Renewables will carry much of it. But economies still need power that doesn't depend on weather, geography or imported fuel.

Fusion is the most abundant answer we know. A gram of fuel holds the energy of twelve tonnes of coal. The fuel comes from water and lithium, and is virtually limitless. Fusing it emits no greenhouse gases and leaves no long-lived high-level waste. And because fusion reactors are machines, you can place them anywhere, size them to the output you need, and deliver power around the clock.

A century of science has carried fusion an extraordinary distance. Today, the effort to turn it into a commercial technology moves in two streams.

The first builds on the approaches we know best: tokamaks, stellarators, and laser fusion, with decades of proven plasma science behind them. Their path to market has mostly been to build and operate an entire power plant, with a big, bespoke machine at its center.

The second explores newer concepts, promising leaner, more compact machines that could one day be built and sold like products. They're moving fast, but most are still early in proving their physics, with many machines and many years of iteration ahead before there's a product someone can buy.

Both are pushing fusion forward, and both are needed. But there's a gap between them. The first stream has the proven physics, but builds on it one large plant at a time, in big, expensive steps that each move it only a little further towards the actual commercial reactor. The second has the ambition to build products, but is still proving the science. What an energy market needs sits right in that gap: a machine built on proven science, made as a product,

POUND FOR POUND

The easiest fuel to fuse here on Earth, in the conditions a machine can create, is a mix of deuterium and tritium. Deuterium is a heavy form of hydrogen; every cubic metre of seawater holds about 33 grams of it. Tritium, the other half of the fuel, is a radioactive form of hydrogen and is rare in nature, so the reactor breeds it from lithium while it runs. When one gram of deuterium–tritium fuel fuses, it releases about 340 GJ of heat. A tonne of hard coal holds about 29 GJ. So one gram is worth about twelve tonnes of coal.

affordable and repeatable anywhere. Until that gap closes, fusion will keep feeling “thirty years away”, too expensive and too late to matter for the decades when the climate and economy need it.

That’s where Starforge comes in. We combine the solid ground of the first stream with the ambition of the second. We obsess over one thing: designing and deploying fusion reactors as products, today.

We do it because every complex technology that became cheap and scaled everywhere, from jet engines to wind turbines, got there the same way. It stopped being built as a one-off and started being built as a product. Fusion can do the same, for one simple reason:

Fusion reactors are machines. So we build them like machines.

In a fission power plant, the reactor is a vessel that holds the fuel, inside a concrete containment, built on site, one at a time. A fusion reactor is different. There’s no store of fuel inside it waiting to react – it makes the conditions for fusion only while it runs, using all of the subsystems as a coordinated machine. There is no large fuel inventory and no giant containment to build around it, so the reactor can be made of modules that factories build in series and that can be swapped out. That puts it much closer in kind to a jet engine or a gas turbine than to a fission vessel.

And yet, as a field, we keep designing our reactors as one of a kind, built on site. That approach has a telling track record. In most Western countries, building a large fission plant has grown more expensive over the decades, not less. In the US, later plants built to an existing design have often cost more than the first.

By contrast, solar panels are made in factories, and every time the total number of panels ever made doubles, their price falls by around a fifth. Module prices have dropped by about 90% since 2010, and that drop is what turned solar from a niche into the fastest-growing source of electricity on the planet.

Fission is learning that lesson too. A new generation of small modular reactors is betting on factories, economies of multiples, fast global deployment and low maintenance downtime. We think they’re right. We also think fusion is even better suited to it.

The Minimum Viable Reactor

It starts before the factory. A factory makes a product: something defined, standardized, and repeatable. So first we had to define

FISSION MATH

A global study of 33 completed fission projects found that what drives the cost of nuclear plants are early design choices and the way they’re delivered. And those costs ran away. Vogtle 3 and 4, the latest nuclear power plants built in the US, were estimated at $14 billion in 2008 and finished in 2024 at about $35 billion. In those studies, across 349 reactors in seven countries, South Korea stood out as its costs fell by about half over 25 years – because it built one standard design with the same crews and suppliers. That’s a real drop, but would be too slow and too local to make fusion cheap. A site crew can’t follow its plants around the world, and each plant is still built one at a time. We believe that the only way to turn this around is through a factory. *Ingersoll et al., The ETI Nuclear Cost Drivers Project (2018); Lovering, Yip & Nordhaus, Energy Policy 91 (2016); Georgia Power (2024).*

what a Starforge reactor as a product actually is. We call it the Minimum Viable Reactor (MVR): the minimum set of things that must be true, all at once, for a fusion reactor to be something someone can actually buy and use.

Starforge MVR is a framework of seven criteria:

1. **MVR must work, provably, from today's data and scaling laws, with no intermediate machine needed.**
   It must produce net energy using validated physics and engineering at subsystem level.
2. **MVR must operate continuously or near-continuously.**
   The reactor and turbine together must deliver continuous output; the reactor alone does not need to.
3. **MVR must be the right size for real asset buyers (50–500 MWe).**
   It must fit within modern and realistic electricity grid procurement envelopes.
4. **MVR must get cheap enough to build without government support.**
   It must be designed so that the reactor class it initiates is financeable with private capital.
5. **MVR must last long enough to pay back the capital invested in building it.**
   It must have a 40+ year operating lifetime with pre-scheduled active maintenance.
6. **MVR parts must depend only on an existing industry.**
   It must only depend on supply chains that exist or are in active industrial development with a credible path to fusion-relevant qualification within the reactor's procurement timeline.
7. **MVR must be as simple as possible.**
   It must have the simplest possible bill of materials consistent with satisfying all previous criteria.

We held every approach in the field up against those criteria, with no favourite going in. Many meet some of them very well. Today, the spherical tokamak is the only one that meets them all, or gives us a platform to design the rest onto.

It's a machine class we can design as a commercial product with confidence, built on decades of tokamak data and well-validated scaling laws.

It's the most fusion-power-dense machine class you can build

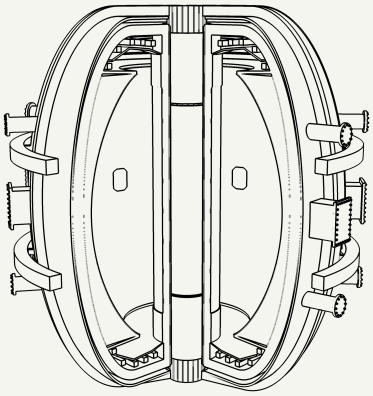

Figure 1: **Starforge Unit One, pre-concept, spherical tokamak.** A tokamak squeezed into the shape of a cored apple rather than a doughnut. The compact shape holds more plasma pressure for the same magnetic field, so the machine can be smaller.

today. Most of its volume makes fusion power, so it can be small and still pay for itself with very favorable unit economics. That's what lets economies of multiples beat economies of scale.

Based on that spherical tokamak platform, we design our MVR – Unit One – to be simple. Our goal is a machine designed as smaller modular pieces, made in a factory, assembled on site, swapped out, and, over time, upgraded. It can be serviced fast. Its compact, low-aspect-ratio shape, re-mountable magnets, and remote handling gives short, easy access to the parts that wear, so maintenance windows stay short, and downtime stays low.

It fits the market as it is. Roughly 70% of the world's large power plants are between 50 and 500 MW,[1] and energy is becoming decentralized. Data centers, industrial sites, district heating networks, and regional grids need hundreds of megawatts, not gigawatts. A 250 MWe unit lets a buyer start with exactly what they need and add more as demand grows, instead of betting everything on a single multi-gigawatt project.

And it can be deployed as a fleet. Several units on one site, or across a grid, behave like one large, but more efficient, power plant. We design each reactor for a maximum of a three-month service every five years. In a plant of four, those services take turns, so the plant never stops generating and runs about 95% of the time (a single large fusion reactor, serviced for about a year each time, would go dark for every service and run about 75 to 85% of the time). And each new unit can start earning while the next is still being built, so capacity and revenue grow step by step.

The criteria will keep guiding our choices as the design matures. From here, our plan follows in four steps.

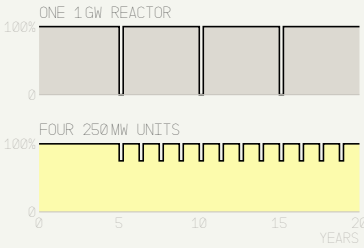

Figure 2: **Same service, steadier power.** Each small reactor needs a maximum of three months of service every five years. One large reactor would need around a year and the plant goes dark each time. Four smaller units take turns, so the plant never stops and averages at about 95% availability.

[1] Starforge analysis of the WRI Global Power Plant Database v1.3 (2021), 34,936 plants, about 72% of global capacity.

The plan

STEP 1: SKIP ONE-OFF LAB PROTOTYPES. BUILD THE FIRST REACTOR AS A PRODUCT.

A technology demonstrator and a commercial reactor are typically designed and built to answer different questions. A demonstrator has to prove a point once: reach a plasma condition, hit a number, run long enough to measure it. A commercial reactor has to make power every day for decades, be serviced on a schedule, be licensed, and be built again for less. Those requirements lead to different machines: different materials, different tolerances, different access for maintenance, different suppliers, and so on. That's why so little carries over from one to the other.

A demonstrator also teaches you how to build that one machine, by hand, from bespoke parts. When it's time to build a factory-made product, almost everything has to be redesigned: the parts, the suppliers, the assembly, the testing, and so on. That's a second development cycle, with its own 5–8 years and its own billions.

So we skip it. And we can, because of the machine class we chose. Tokamaks have produced fusion again and again, from the early 90s. In 2023, Europe's JET set a record of 69 megajoules of fusion energy in a single six-second pulse, and in 2025, China's EAST held a high-performance plasma for almost eighteen minutes. Decades of research across more than two hundred machines provided leaps in understanding of what it takes to create conditions for fusion plasmas, and how gain grows with size and magnetic field is well understood. On that foundation, a demonstrator would mostly prove what we already know how to design for. So our first reactor is designed for the high gain from the start, and against the stricter requirements of a commercial reactor. It will show that gain while operating as a machine on a customer's site, delivering power for decades.

Our first reactor is engineered the way every one after it will be built: from production-ready modules, made with the suppliers and processes we'll later scale. That's why our first reactor is our tech demonstrator, our first-of-a-kind and our first product, all in one machine.

LEARNED IN THE FIELD

Wind and gas turbines didn't wait until every question was answered. The first Danish wind turbines built in series in the early 1980s made around 55 kilowatts. Today's make hundreds of times more, and most of what changed along the way was learned from turbines already running. Gas turbines in power plants followed the same path: generation after generation, built in factories and improved in the field, until the best combined-cycle plants passed 60% efficiency. Once the core of a machine is understood well enough to design with confidence, it becomes a product, and the remaining questions get answered inside the product line, one unit and one service cycle at a time.

STEP 2: SELL IT INTO THE ENERGY SYSTEM THAT ALREADY EXISTS.

Starforge is a reactor vendor. We design, manufacture, sell and service the reactor and its fusion systems as the plant's fusion island, the part where the heat is made. Everything around it, the turbines, the switchyard, the grid connection, the site itself, is already an industry, with companies that know exactly how to build it.

In much of the world, fission's industry splits into clear roles between technology vendors, who design and supply reactors, turbines, and other adjacent equipment, and developers and operators, who build and run the plants. Each side builds its organisation around one clear job.

And because licensing is national, selling reactors rather than owning plants is the practical way to reach every corner of the globe.

We follow the same model. Our customers are the companies that already build and run power plants: utilities and independent power

WEAR AND TEAR

Every deuterium-tritium fusion reactor, whatever its design, wears out from the inside: the neutrons that carry its energy also wear down the parts within the reactor. Without servicing, those parts typically last years, not decades, and the hardest-working ones far less. That's why every reactor we sell comes with decades of service as planned maintenance, replacement modules and upgrades, for the forty years or more it runs. Without servicing, a fusion reactor is a write-off. With it, it's a forty-year asset.

producers, municipal and district heating operators, state-backed energy companies, and industrial groups and data center operators that run their own power. They own the plant and hold the license to operate it. We certify one standard design, with standard interfaces to the rest of the plant, and supply it into local energy ecosystems around the world, instead of rebuilding a project company in every country.

STEP 3: RAMP THE FACTORY TO FULL RATE.

Factory thinking starts on day one. We design every part of our reactor for manufacturing and for servicing from the very first sketch, and our first reactor is built from production-line pieces, made with the tools, processes and suppliers we'll scale. So the factory doesn't start after the first reactor. It has to start with it.

Our factories will build the reactor's modules: made on a line, tested before they leave, shipped by road, rail or sea, and assembled on site. Work that would otherwise stretch over years on a construction site moves into a controlled environment, with the same teams doing the same jobs, better every time.

At full rate, our first (giga-)factory will make four reactors a year, shipped across the globe, along with the replacement modules every reactor in the field needs, so every reactor we sell keeps the line busy for decades.

STEP 4: USE THE FACTORY TO MAKE EVERY REACTOR CHEAPER, AND DESIGN THE NEXT ONE.

This is where the learning curve takes over. Every time total production doubles, the cost of building the reactor falls by around 15%. By our eighth reactor, it costs roughly 40% less than the first. A one-off plant never gets there: at best, the next one is a few percent cheaper.

We don't claim that smaller is cheaper by itself. The most detailed comparison of large and small fission reactors found that modular design alone barely moves the cost. What moves it is building the same unit again and again, in factories, which cut capital costs by 30 to 45%. Building smaller unlocks serial production, and serial production unlocks learning.

Our own analysis shows where the savings come from: almost all of it comes from the factory, and from a design built to be serviced with a pre-defined 40+ years by plan, which spreads the capital cost over decades of output.

The fleet makes us better too. Every reactor in the field teaches

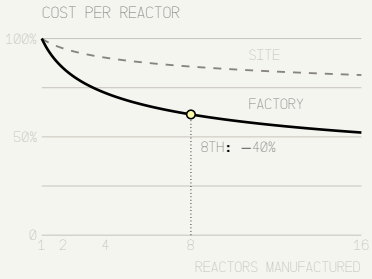

Figure 3: **Every doubling, 15% cheaper.** Built in series in a factory, the reactor gets about 15% cheaper each time the number built doubles. By the eighth, it costs about 40% less than the first. Site work learns more slowly in practice: a local crew gets few doublings, and the next project is a few percent cheaper at best, which is what the South Korean fission construction story from pg 2 confirms.

us something: how parts wear, how long they last, what could be simpler. Those lessons go into the digital twins and the next service cycle, so reactors that are already running get better components without being replaced.

And they go into what comes next. Our first reactor product line is the first in a catalog, not the only one. Every machine we build teaches us how to design the next one, for new sizes and new uses, from electricity to industrial heat.

In short: build a reactor someone can buy, and keep it serviced for decades. Sell it to the people who already know how to run power plants. Use what we learn to ramp the factory to full rate. Use the factory to make fusion cheap, deploy it everywhere, and to build what comes next.

We are designing for our first reactor to deliver electricity to the grid by 2037, and for a factory building four reactors a year from 2040.

Fusion has had its great moments of scientific breakthrough. Now, as it turns into a commercial technology, price, scale and timeline become the bar. We built Starforge to give fusion a chance to clear it.



Dr. ir. Ana Koller
STARFORGE GMBH



Jonathan Janssen
STARFORGE GMBH

Fusion. Built simply to power the planet.

Forward-looking statements. This document describes Starforge's plans, targets and expectations, including timelines, production rates and costs. These are forward-looking and depend on technical, regulatory and market developments; actual results may differ. © 2026 Starforge GmbH. All rights reserved.