Zap Energy

Coil-free Z-pinch fusion developer now betting on fission too

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Develops a sheared-flow-stabilized Z-pinch fusion device and, as of 2026, an advanced sodium-cooled fission reactor under an "integrated nuclear" strategy.

COMPANY	Zap Energy	HEADQUARTERS	Seattle/Everett, Washington, USA
OWNERSHIP	Private	TOTAL RAISED	Over $330M (contested; see body), 2017–2024
CEO	Zabrina Johal		

ABSTRACT

Zap Energy is a University of Washington fusion spin-off pursuing the sheared-flow-stabilized (SFS) Z-pinch, a confinement scheme in which an electric current driven through a plasma column generates its own magnetic field while a "sheared flow" velocity gradient holds the plasma together. The distinctive bet is architectural: no external superconducting magnet coils, no cryogenics, and no lasers, which the company argues makes for a simpler, cheaper machine than tokamaks or laser-fusion rigs. In spring 2026 Zap reframed itself as an "integrated nuclear" company, adding development of an advanced sodium-cooled fission reactor in the ~10 MWe range alongside fusion, with the stated goal of reaching revenue sooner. The implications are threefold: the physics path to breakeven remains unproven and capital-intensive, the fission expansion is real but its funding and synergy are undisclosed, and Zap is now competing in two regulated nuclear markets at once.

Keywords: Zap Energy; sheared-flow-stabilized Z-pinch; fusion energy; advanced fission; integrated nuclear; FuZE-Q; plasma physics; DOE milestone program

1. Snapshot

Zap Energy (zapenergy.com) is a privately held nuclear-energy company spun out of University of Washington research, with Lawrence Livermore National Laboratory collaborators, on the sheared-flow-stabilized Z-pinch. It was founded in 2017 and operates in the Seattle/Everett, Washington area, though sources disagree on the precise legal headquarters. The company cites over $330 million raised to date, including a $160M Series C in June 2022 (Lowercarbon Capital, Breakthrough Energy Ventures, Shell Ventures) and a $130M Series D in October 2024 led by Soros Fund Management. Note that figure is contested: the named rounds sum to $290M, and a separate reference describes the president as having led "more than $200M" in fundraising, so the totals do not reconcile. In spring 2026, Zabrina Johal was appointed CEO, with co-founder Benj Conway as President. Key diligence gaps remain private: revenue (presumably none from energy sales), headcount, valuation, and how the new fission program will be funded.

2. Thesis: Why This Company, Why Now

The bet is that the cheapest road to fusion is the one that throws away the most expensive hardware. Mainstream approaches rely either on enormous superconducting magnets and cryogenics (tokamaks, the donut-shaped magnetic-confinement devices that dominate fusion research) or on building-sized laser arrays (inertial confinement). Zap's SFS Z-pinch dispenses with both: the plasma confines itself with a field generated by its own current. If the physics holds at power-plant scale, the capital and engineering burden could be dramatically lower, which is the entire commercial argument, though no independent techno-economic analysis has validated the magnitude of that claim.

What changed in spring 2026 is more pointed. Zap reframed as an "integrated nuclear" company and added an advanced sodium-cooled fission reactor in the ~10 MWe range, explicitly to reach revenue and commercialization faster. That is a tacit acknowledgment that fusion's timeline is long and uncertain, and that a fission product targeted for the early 2030s could fund the company in the interim. The reachable near-term market is therefore advanced fission, not fusion. The fusion market remains entirely prospective and unpriced.

3. The Core Idea in Plain English

Think of a Z-pinch as a lightning bolt that squeezes itself. When a large current flows through a conducting plasma, the magnetic field that current generates wraps around the column and compresses it inward, the same physics that makes a wire carrying current attract a parallel wire. Do that fast and hard enough and the plasma gets hot and dense enough to fuse. The historical problem is that the compressed column is violently unstable: it kinks and sausages apart in microseconds. Zap's contribution is to impose a velocity shear, a gradient in the plasma's axial flow speed, that suppresses those instabilities without any external hardware. Old world: confine the plasma from the outside with massive, cryogenically cooled magnets. New world: let the plasma confine itself, so the machine is small, coil-free, and in principle far cheaper to build and iterate.

4. The Technical Space

The underlying problem is confining a plasma hot and dense enough, for long enough, that fusion reactions release more energy than was spent heating and containing it. The standard yardstick is the triple product of density, temperature, and confinement time, summarized commercially as Q, the ratio of fusion power out to power in. Q>1 is scientific breakeven; a power plant needs much more after accounting for recirculating power.

Three approaches dominate. Magnetic confinement (tokamaks, stellarators, the twisted-coil variants) uses external superconducting coils and is the best-funded path, but the magnets, cryogenics, and structure are enormous and expensive. Inertial confinement compresses fuel pellets with lasers; Lawrence Livermore's facility achieved target gain, but at low repetition rate and gigantic cost. Pinch and compact schemes, including the Z-pinch, trade simpler hardware for harder stability physics, since current-carrying plasma columns are notoriously prone to disruptive instabilities.

What "good" looks like here: temperatures of a few to tens of keV (kiloelectronvolt, used as a temperature proxy), high plasma pressure with a credible route to Q>1, repetitive high-frequency operation rather than single shots, and components that survive a neutron-and-heat environment. The historical knock on Z-pinches has been precisely that instability problem, which is exactly what Zap's sheared-flow scheme claims to solve.

5. How Their Technology Works (and What's Proprietary)

Zap's device architecture decomposes into three interlocking components, anchored by peer-reviewed Physics of Plasmas work and ARPA-E technical documentation. Importantly, it remains a magnetic-confinement scheme, not "magnet-free": the field is real and strong, it is simply self-generated by the plasma current.

- **Pulsed-power driver and FuZE devices.** A current pulse, targeting roughly 650 kA in the fourth-generation FuZE-Q device, is driven through a coaxial electrode assembly fast enough to compress the plasma before instabilities grow. FuZE-Q began operating in June 2022 and is *designed* to reach scientific breakeven (Q>1) around that ~650 kA figure. This is a design goal, not an achievement: by Zap's own calculations plasma pressure must still increase at least tenfold to get there. Reported device-specific milestones across the FuZE lineage, all self-reported and not independently replicated, include 5,574 neutron-producing plasmas in 2023 (one shot above 1.5 billion neutrons) and 1–3 keV electron temperatures (11–37 million °C) on FuZE in April 2024. A separate device, FuZE-3, reported plasma pressures of 1.6 GPa in November 2025; these milestones span different device generations and should not be conflated.
- **Sheared-flow stabilization.** A controlled axial velocity gradient, faster at the center and slower at the edges, applies a shearing force that suppresses the sausage and kink instabilities that historically destroyed Z-pinch plasmas. The underlying physics is peer-reviewed and published; the engineering implementation is where any edge would live.
- **Liquid-metal wall (Century platform).** Operational since October 2024, Century tests power-plant-relevant subsystems: repetitive pulsed power and liquid-metal walls. It demonstrated over 1,000 consecutive plasma shots in under three hours and met a DOE milestone by sustaining plasmas in a liquid-metal environment for three hours without failure.

What is proprietary versus replicable? The SFS Z-pinch concept is in the peer-reviewed literature, and national labs collaborated on the origin. A likely proprietary layer is the integrated engineering: electrode geometry, flow-shear control, pulse-shaping, diagnostics, and liquid-metal handling. That is an inference based on typical fusion-commercialization stacks, not a claimed patent position. A well-funded competitor or national lab could pursue the same physics; the harder thing to copy quickly is the operational knowledge embedded across four device generations. The moat is execution lead, not an unbreachable patent wall.

6. Business and Go-to-Market

There is no commercial product or revenue today; both nuclear programs are pre-commercial. The clearest near-term commercial logic is the spring 2026 shift toward fission. Zap now positions an advanced sodium-cooled fission reactor in the ~10 MWe range as a revenue product targeted for the early 2030s, with fusion as the longer-horizon prize. That sequencing matters commercially: fission has a real, regulated market and a buildable product, whereas fusion remains a research program.

The company frames the dual strategy as leveraging overlapping technologies, particularly liquid-metal cooling, to reduce risk and reach a paying customer faster. That synergy rationale is company framing and has not been independently corroborated; the peer-reviewed strategy paper and ARPA-E/IAEA technical descriptions are fusion-only. Critically, the company has not disclosed how the fission program will be funded, and no partnership or licensing arrangement with any established fission IP holder has been made public, which makes it hard to judge whether the strategy has backing beyond a press release.

Funding has come from venture capital rather than customers, via the named Series C and Series D rounds. Non-dilutive validation matters here too: Zap was selected in May 2023 as one of eight companies in the U.S. Department of Energy's Milestone-Based Fusion Development Program, though the specific financial terms remain undisclosed.

7. Competitive Landscape and Moats

Zap competes across two cohorts. In fusion, the comp set includes Commonwealth Fusion Systems (high-temperature superconducting tokamak), TAE Technologies (field-reversed configuration), General Fusion (magnetized target with mechanical compression), and Helion Energy (a fellow Washington-state pulsed-magnetic approach). The closest direct rival is Helion Energy, also pursuing a pulsed, non-tokamak scheme with aggressive timelines.

Where Zap wins against Helion. Its coil-free SFS Z-pinch is mechanically simpler, with peer-reviewed stability physics and a device explicitly designed toward Q>1, plus a focused campaign on liquid-metal walls and repetitive pulsed power via Century. Where it loses. Helion has emphasized direct electricity conversion and tight integration of pulsed magnets with recuperation; if repeatability and component longevity arrive sooner there, Zap's path looks longer. Both must still demonstrate physics sufficiency and plant-relevant duty cycles. Commonwealth bets that better magnets solve the problem where Zap bets on eliminating them; TAE and General Fusion are further along in operating history. On the fission side, Zap enters a field of advanced microreactor developers with years of regulatory work behind them, but its public materials name no specific rival.

Three moats merit attention.

› **Accumulated experimental data.** Zap's multi-generation run history is genuinely proprietary and compounding, since instability suppression and component life are empirical. It is also self-reported and not independently replicated.

› **System simplicity, if it scales.** Eliminating external superconducting coils removes a whole class of cryogenic and structural systems. This moat is real but conditional on the physics working at higher current.

› **DOE program position.** Selection into the milestone cohort is a credibility and validation moat, not a financial one given undisclosed terms.

The platform risk is straightforward: the core physics is published and lab-originated, so a national lab or far-better-funded rival could out-execute on the same physics.

8. Risks and Open Questions

The dominant risk is that the physics does not scale: a design goal of Q>1 is not breakeven, and the literature supports "scaling toward" it, not proximity. The fission expansion adds a second category, regulatory and commercial, in a market where licensing timelines are brutal. The questions I would put to the founders:

- By Zap's own model, plasma pressure must rise at least tenfold to reach breakeven; what is the credible timeline and capital requirement to close that gap while maintaining stability and shot-to-shot repeatability?
- How is the new fission program funded and staffed, and is there any partnership or licensing arrangement behind the ~10 MWe sodium-cooled design, or is it a strategic narrative ahead of the next round?
- Does liquid-metal cooling genuinely transfer between the fusion and fission programs, given that the peer-reviewed and ARPA-E/IAEA technical descriptions are fusion-only?
- How are electrode erosion, impurity control, and pulse-power thermal loads trending as shot counts scale toward plant-relevant duty cycles?
- How does the contested capital total reconcile, given that the named rounds sum to $290M against an "over $330M" claim?

9. Bottom Line

Zap has the most architecturally distinctive physics story among coil-free fusion startups, but breakeven remains a design goal requiring a tenfold pressure gain, not an imminent result. The single biggest reason it could work is architectural: eliminating superconducting magnets, cryogenics, and lasers genuinely lowers the cost and iteration burden if the stability physics holds at scale. The one thing to watch next is whether the spring 2026 fission expansion materializes into a funded, partnered ~10 MWe product or stays a press-release strategy, because that determines whether Zap reaches revenue before its fusion capital runs out.

10. For the Nerds

The whole edifice rests on whether sheared-flow stabilization continues to suppress the m=0 (sausage) and m=1 (kink) magnetohydrodynamic instabilities as current scales toward ~650 kA. Velocity-shear stabilization is confirmed in the linear regime at the few-hundred-kiloampere range; the open question is whether it holds in the nonlinear, higher-current regime where breakeven lives, especially as the pinch gets hotter and denser and the stability window may narrow. The IAEA notes key SFS Z-pinch regimes are still under active investigation, which is the honest framing. Diagnostics that reconstruct time-resolved velocity and magnetic profiles under high dI/dt are critical, and pulse-shaping limits in the power electronics may matter as much as the plasma physics.

Century's liquid-metal environment raises a coupled materials-and-MHD problem. Flowing metal under strong transient magnetic fields experiences Lorentz forces that can thicken boundary layers and alter heat transfer, and any turbulence or impurity injection feeds back into the pinch, since even small-Z contamination can quench temperatures at keV levels. Whether the liquid-metal surface preserves the near-wall velocity profile the shear scheme depends on is an open question, not an asserted coupling. Demonstrating three hours is encouraging; translating that to decade-scale duty cycles, while managing corrosion and electrode wear, is the unglamorous problem that ultimately decides commercial viability.

WHERE SOURCES DISAGREE

Date of the integrated-nuclear announcement and CEO appointment

One reading, from the PR Newswire dateline and GeekWire coverage, places it on April 28–29, 2026. Other reports date it to May 6, 2026, and to June 2026

Unresolved: the source documents themselves carry conflicting datelines, so "spring 2026" is the most defensible framing

Whether the fission expansion is a "pivot"

The company's framing insists it "isn't a pivot," casting fission and fusion as "two expressions of the same underlying physics" integrated to reduce risk. At least one news account characterizes it as a partial pivot

Unresolved: this is a framing dispute rather than a factual one, and the evidence supports neither characterization as objective truth

Whether the fission strategy is financially real

The company presents fission as a synergistic, revenue-accelerating program. Reporting notes the company did not disclose how the fission effort will be funded and that no partnership or licensing arrangement with Toshiba (which holds relevant 4S intellectual property) has been made public

Unresolved: , as the reporting itself states, without those details it is hard to judge whether the strategy has backing beyond a press release

Whether shared technology genuinely links the fission and fusion programs

The company asserts overlapping technologies such as liquid-metal cooling reduce risk and speed development. The peer-reviewed strategy paper and ARPA-E/IAEA technical descriptions are fusion-only and treat liquid-metal walls solely as a fusion heat/neutron component, with no fission roadmap

Unresolved: independent technical sources neither corroborate nor disprove the synergy — it currently rests on company communications alone

Distance and timeline to fusion breakeven (Q>1)

The company describes FuZE-Q as designed to reach Q>1 around ~650 kA. The available technical literature frames current devices as *scaling toward* breakeven and notes plasma pressure must rise at least tenfold first, with no date and no commercial-fusion timeline given

Unresolved: the corpus contains a design goal and a stated gap, but no verified achievement or schedule

Total capital raised ($200M vs. $330M)

One reading cites "over $330 million" raised to date. Another corpus reference describes the president as having led "more than $200 million" in fundraising, and the two named rounds ($160M + $130M) sum to $290M, not $330M

Unresolved: the sources use different aggregation bases and the figures do not reconcile to a single settled total