**Mainspring Energy Tech Library**

**Company Overview**

Mainspring Energy, Inc. is a clean energy technology company based in Menlo Park, 1 2

California, focused on developing a new category of power generation: the linear generator . The company was founded in 2010 by three Stanford University engineering Ph.D. students – **Shannon Miller**, **Matt Svrcek**, and **Adam Simpson** – who sought to improve the efficiency of distributed power generation

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. Mainspring’s mission is to advance global access to low-carbon, dispatchable energy by delivering 5

breakthrough onsite power solutions . The founding team spent nearly a decade in R&D (developing and 6 2

testing three prototype generations) before launching its first commercial products in 2020 . Backed by top-tier investors such as Khosla Ventures, Bill Gates, and others, Mainspring has raised significant 7 8

capital to scale its technology and business . Key highlights in the company’s history include:

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**2010:** Founded as **EtaGen** by Shannon Miller (CEO), Matt Svrcek (CTO), and Adam Simpson (Chief 3 4

Commercial Officer) at Stanford’s Advanced Energy Systems Lab . Initial seed funding was provided by Khosla Ventures.

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**2020:** Rebranded to **Mainspring Energy** as the company prepared to commercialize its linear 1

generator technology . Began first customer installations, entering the ~$750 billion global 9

electrical equipment market for onsite power .

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**2021:** Unveiled the 250 kW **Mainspring Linear Generator** as a new product. Announced a $150 million purchase and deployment agreement with NextEra Energy (parent of Florida Power & 10

Light) to install Mainspring generators across the U.S. . Raised a $95 million **Series D** investment 8

led by Devonshire (Fidelity), bringing total funding to $228 million . Early pilot units were deployed with Fortune 100 customers like Kroger and with utility Pacific Gas & Electric (PG&E) for 11 12

microgrid resiliency .

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**2022: Fuel-flexibility breakthrough –** demonstrated successful operation on 100% hydrogen and 13

100% ammonia fuel, without hardware modifications . Closed a **Series E financing** of 14 15

$290 million (led by Lightrock), bringing cumulative funding to over $500 million . Entered strategic pilot projects, including a memorandum of understanding with utility AEP (American 16

Electric Power) for multi-unit trials and a 100% landfill biogas pilot installation in Yolo County, 17

California .

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**2023:** Won a **Bloomberg New Energy Finance (BNEF) Pioneers Award** for its role in accelerating 18

deployment of zero-carbon fuels (e.g. hydrogen) in power generation . Continued to grow deployments and manufacturing capabilities.

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**2024:** Expanded operations into Texas via a deal to deploy generators at five **Lineage Logistics** facilities (the world’s largest cold storage company) to provide resilient onsite 20

power . Launched a reseller partner program and formed a strategic partnership with **Schneider** 21 22

**Electric** to integrate Mainspring’s fuel-flexible generators into microgrid solutions . •

**2025:** Announced a **Series F funding** of $258 million to scale production, with new investors 15

including Amazon’s Climate Pledge Fund . This brought total funding to well over $600 million. 1

Added prominent industry leaders to its board and **established a Strategic Advisory Board** of data center and utility experts (e.g. former Microsoft and Google data center executives) to guide growth 23 24

in those sectors . By 2025, Mainspring reported having “hundreds of megawatts” of capacity 25

either operating in the field or in advanced development projects , reflecting the rapid scale-up of its deployments since first shipping units in 2020.

**Technology Overview**

**Mainspring’s Linear Generator** is a novel electromechanical generator that directly converts chemical fuel energy into electricity using linear motion instead of traditional rotary motion. In a Mainspring generator, a mixture of fuel and air undergoes a **low-temperature “flameless” reaction** that drives magnets through 26

copper coils to produce electric current . Unlike an internal combustion engine, there is no spark plug or flame; instead, the fuel/air mix under compression in a controlled reaction, pushing two pistons linearly. This linear motion is converted to electricity via an integrated linear alternator, without 27 28

a crankshaft or turbine . The device’s software actively controls the reaction and piston dynamics to maintain high efficiency and flexibility. This fundamentally different architecture yields a combination of features and benefits that set the linear generator apart from conventional generators:

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**High Efficiency:** By directly converting reciprocating motion into electric power, the linear generator

maximizes the expansion of gases and minimizes mechanical losses. It achieves about **46% net electrical efficiency** (AC) on natural gas – comparable to or higher than many engines or 29

microturbines in its class . High expansion ratios in the Mainspring design allow more energy to be extracted from each fuel charge, and the absence of a crankshaft means no energy is wasted 30

converting linear motion to rotation . This efficiency approaches fuel-cell levels of performance 31

but with a simpler system .

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**Fully Dispatchable & Fast Response:** Mainspring’s generator is designed for **load-following and**

**rapid on/off** capabilities. It can ramp from zero to full power almost instantaneously to match 32

changing demand or stabilize microgrids . The system supports **black starts** (starting up without grid power) and can seamlessly island from the grid, making it ideal as a backup or microgrid 33

backbone for resilience . Precise power electronics enable sub-second adjustments in output, 32

helping balance renewable fluctuations and grid frequency in real time .

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**Fuel Flexibility:** A core innovation of the linear generator is its ability to run on a wide range of

gaseous fuels – including **natural gas, renewable biogas, propane, hydrogen, and even ammonia** 34 35

– and to **switch between fuels on the fly** via software control . The adaptive control system adjusts compression and timing in real-time to accommodate different fuel properties, so the same unit can use conventional fuels today and transition to 100% zero-carbon fuels in the future without 13 35

hardware changes . This “future-proof” fuel flexibility is unique; by contrast, most engines or

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turbines require physical modifications to use hydrogen or other new fuels safely and efficiently

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. Mainspring’s linear generators have successfully demonstrated high-efficiency operation on 13

100% hydrogen and 100% ammonia in testing . •

**Ultra-Low Emissions:** The device’s **flameless combustion** process keeps peak reaction 37

temperatures below the threshold at which nitrogen oxides (NOx) form (around 1,500 °C) . As a result, **NOx emissions are near-zero** – measured **<1.5 ppm** (@15% O₂) which is a >90% reduction 38 39

compared to typical reciprocating engines . Particulate emissions are also extremely low since there is no traditional combustion flame**.** This enables the Mainspring generator to meet the strictest air quality regulations and operate in locations where diesel gensets are restricted due to pollution

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. Greenhouse gas emissions are also reduced relative to the grid when running on natural gas 2

(due to high efficiency), and can be eliminated entirely by using biogas or green hydrogen as fuel

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**Low Maintenance & Cost:** The linear generator’s design has **only two moving parts** (the two 41

oscillating pistons) and uses standard industrial materials . It does **not require oil lubrication** – the pistons are supported by an air bearing system – and it has no complex gearbox, crankshaft, or 41 42

costly catalysts to replace . This simplicity translates to lower upfront cost and maintenance requirements compared to engines or fuel cells. Mainspring expects longer maintenance intervals and life, since there are fewer wear-prone components and operating temperatures are relatively low. (In practice, ensuring long-term durability of the piston seals and moving components is a key 43 44

engineering focus, and Mainspring’s patents reflect innovations in these areas .) Overall, the company touts a cost per kW that is highly competitive, delivering **“the high efficiency and low**

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**emissions of fuel cells with the low cost and dispatchability of engines and microturbines.”**

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**Modular, Scalable Deployment:** Mainspring’s product is packaged in a **turn-key 20‑foot container** 45

with built-in inverters and controls for easy installation . Each base unit currently provides ~250 kW and can operate independently or in parallel with others. The system is **inherently modular** – multiple units can be sited together to reach multi-megawatt scale (up to ~18 MW per 46

acre footprint) . This allows customers to start with a small installation and add capacity as needed. The containerized design and lack of noise (<70 dBA at 3 m) means the generators can be 47

placed in commercial or urban locations with minimal site preparation . The units connect to standard 480 V three-phase electrical infrastructure, and when fueled by pipeline gas (or onsite fuel 48 49

tanks), they provide reliable power on either side of the utility meter .

**Technical Deep Dive**

**Operating Principle:** The Mainspring linear generator operates on a **free-piston linear alternator** concept. At its core is a **reaction chamber** where a mixture of air and fuel is admitted. On each side of this central chamber is a linear electromagnetic machine (stator coils and a moving magnet assembly), and at 50

the outer ends are air-filled chambers acting as “springs” . During operation, a cycle proceeds as follows: fuel and air flow into the central chamber, and **movable pistons (also called oscillators) on each side** 51 52

**compress the mixture** by moving toward the center . When the mixture is compressed to the right conditions, it **causes** a **flameless chemical reaction** – This reaction rapidly releases energy, sharply raising the 51 53

pressure in the chamber . The high-pressure gases push the two pistons **outward** (away from the 28

center), converting the chemical energy directly into kinetic energy of the pistons . As the pistons move outward, the **magnets attached to them slide through the surrounding copper stator coils**, **inducing an electric current** – this is the linear generator’s equivalent of what a rotating generator does with a 28 27

spinning rotor . When the pistons reach the end of their stroke, the outward motion compresses the

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air in the end chambers, creating an **air spring** that then bounces the pistons back toward the center

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. The coils generate additional electricity on the inward stroke as the magnets pass by in the reverse

direction. The cycle then repeats with a fresh charge of fuel-air mixture. Importantly, the compression/ expansion process is **not mechanically constrained by a crankshaft** – the pistons’ motion is controlled electromagnetically and can be adjusted each cycle. This **allows fine-tuned control of the compression** 56 57

**ratio and timing** of the reaction, which is crucial for different fuels and operating conditions . For example, hydrogen fuel reacts at a lower compression than ammonia; Mainspring’s control system can accommodate such differences by altering piston travel and when the reaction is initiated, all via software, 56 58

to always achieve the optimal compression ratio . This adaptive control is a major innovation – it solves the challenge that in a conventional engine with a crankshaft, the

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piston motion is fixed and cannot adapt, making HCCI (homogeneous charge compression ignition) difficult 57

to control . Mainspring’s system actively manages each cycle, which is why it can handle variable fuels and loads while maintaining stable operation.

**Engineering Innovations and Patents:** Mainspring’s design incorporates several patented solutions to enable this novel generator. The company’s patents (over **45 issued U.S. patents and 20 international patents** as of 2024) cover areas such as the piston assembly, sealing and friction reduction, generator 59

control algorithms, and multi-unit operation . One key aspect is the use of **air bearings and advanced** 43 60

**piston seal assemblies** to allow nearly frictionless motion of the oscillators without lubrication oil . Traditional piston engines require oil to reduce friction and seal the combustion gases, but Mainspring’s linear generator avoids oil by using a cushion of air and specially engineered seals, eliminating oil changes and the risk of oil-related emissions or maintenance . Another patented area is the **adaptive control**

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**system** that monitors piston position, velocity, and chamber pressure in real time and adjusts the input energy each cycle. This control software, together with modern power electronics, effectively makes the linear generator’s operation **software-defined**, allowing features like precise load following and fuel switching with a simple software update . The generator’s power electronics also handle grid

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synchronization and conversion of the variable-frequency generated AC into stable output power, including 62 63

meeting UL 1741 SA requirements for grid interconnection . Because the linear generator ties the mechanical motion directly to electrical generation (the pistons slow down as they generate electricity, providing inherent damping and control), it avoids the uncontrollable “explosive” combustion problem of free-piston engines in the past. The result is a machine that can achieve high efficiency in a real device, not just in theory: early testing showed the flameless reaction approach can be as efficient as a fuel cell in extracting energy . Mainspring’s successful prototypes and field units have validated the core

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technology, and the company continues to refine aspects like power scaling (for larger units), durability (e.g. ensuring the oscillators and springs last for many millions of cycles), and integration with energy storage and control systems. Overall, the **intellectual property** and engineering know-how Mainspring has accumulated over 14+ years give it a significant head start in the linear generation field; industry analysts have noted that Mainspring appears to have “locked up” key IP for linear generators, creating a moat 43 65

against potential competitors in this space .

**Products and Deployments**

**Product Specifications:** Mainspring’s first commercial product is a **250 kW (0.25 MW) linear generator** system, packaged as a ready-to-install unit. Each system consists of two 115 kW linear generator cores 66 67

working in tandem inside a standard shipping container (approximately **20.5’ × 8.5’ × 9.5’** in size) . The generator produces **400–480 V three-phase AC** output, suitable for commercial and industrial power 68

needs . Key specs of the Mainspring Linear Generator product include:

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**Rated Output:** 250 kW\_net (AC) per containerized system. Multiple units can be paralleled for multi 69

megawatt projects (e.g. >1.5 MW installations use several modules with external inverters) . The technology is highly scalable – an array of Mainspring units can achieve power densities up to 46

~18 MW per acre .

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**Fuel Input:** Compatible with **natural gas, biomethane (landfill or digester gas), propane,**

**hydrogen, and ammonia** (in various blends or 100%). Fuel is supplied at 5–20 psig pressure (low 70

pressure gas pipeline or tank) . No external water supply is required (unlike fuel cells or some 71

engines that need water for cooling or exhaust treatment) .

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**Electrical & Control:** The unit integrates grid-tie inverters and control systems and is certified to 63

**UL 2200** (stationary generator) and **UL 1741 SB** (advanced inverter) standards . It supports **remote monitoring and control**, allowing it to participate in microgrid control or demand response programs. Power quality is actively managed by the inverter, providing stable frequency and voltage to the customer load or grid as needed.

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**Performance:** ~**46% net electrical efficiency** (LHV) on natural gas or biogas, measured at full load 72

(15 °C, 1 atm) . Notably, the efficiency remains high even at part loads, since the linear generator can modulate output without throttling losses (unlike combustion engines that lose efficiency when partially loaded). The unit can **ramp from 0 to 250 kW in seconds**, and supports unlimited on/off 33

cycling, making it well-suited for intermittent operation or following solar output .

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**Emissions & Noise:** Certified **<1.5 ppm NOx** (@15% O₂, dry) without aftertreatment – essentially **no** 47

**exhaust after-treatment required** to meet even California’s stringent air quality rules . CO and VOC emissions are also very low due to the lean, flameless combustion. **Sound level <65 dBA at** 47

**10 m** distance (about the noise of a normal conversation) . This quiet operation is achieved through acoustic insulation of the enclosure and the inherently smoother operation of linear motion (no loud explosions or high-speed turbines).

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**Maintenance:** Expected maintenance is infrequent – there are no oil changes (the system is oil-free),

and no consumable catalysts. The primary scheduled service would be inspection or replacement of air filters, and long-term refurbishment of seals if needed. Mainspring has not publicly disclosed mean time between maintenance, but emphasizes a low total cost of ownership due to minimal 41 42

maintenance and high efficiency .



*Mainspring’s 250 kW linear generator system installed in its enclosure (about the size of a parking space). Each unit contains two linear generator cores and built-in power electronics, delivered as a turn-key container for easy deployment.*

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**Deployment Scenarios:** The flexibility of Mainspring’s generators enables a wide range of applications on 48

both the **customer side** and the **utility side** of the meter . Common deployment scenarios include:

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**Commercial & Industrial (C&I) Onsite Power:** Many early Mainspring units have been installed at commercial facilities to provide **peak shaving, backup power, and cost savings**. For example, the grocery chain **Kroger** deployed Mainspring generators to cut energy costs and ensure backup power 11

at stores . The units run on pipeline natural gas but can switch to biogas or hydrogen blends as 73

those become available, aligning with corporate sustainability goals . Data centers and manufacturing plants are also target customers, using linear generators for reliable on-premises generation that can offset grid usage and provide resilience. In one high-profile deployment, a cluster of Mainspring generators was installed to power **the largest electric truck charging depot** 74

**in the U.S.**, operated by Prologis and Maersk in Southern California . By providing on-site generation, this project avoids straining the grid during EV charging and ensures the depot has round-the-clock power for fleet operations.

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**Microgrids and Utility Grid Support:** Mainspring has partnered with utilities to use linear

generators in **community microgrids and substations**. Notably, in 2021 **PG&E** piloted a 240 kW Mainspring generator in Napa County, CA, at a microgrid site to provide backup power during 12 75

wildfire-related outages . The unit runs alongside (and is expected to eventually replace) a diesel genset, dramatically reducing local air pollution while improving reliability. Because the Mainspring can ramp quickly and respond to automatic generation control signals, it can also help regulate voltage/frequency on the grid. **American Electric Power (AEP)**, a major utility, signed an 76

agreement in 2022 to pilot Mainspring generators for distributed grid support in their territory . These utility deployments demonstrate that linear generators can provide **“virtual power plant”** capabilities – acting as distributed power assets that utilities dispatch as needed for capacity or balancing, especially as more solar and wind come online.

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**Renewable Firming and Remote Sites:** Mainspring units are being used to **firm renewable energy**

and power remote sites. For instance, **Yolo County** in California is piloting a Mainspring generator 17

running on 100% landfill **biogas**, turning a waste methane stream into useful electricity on-site . This project highlights the generator’s ability to use low-BTU fuels that might be challenging in engines. In remote or off-grid locations, Mainspring generators (due to black start and islanding capability) can serve as the primary power source or work in concert with solar panels and batteries to form a reliable microgrid. They offer an alternative to diesel gensets for telecom sites, islands, and remote communities, especially where fuel availability might shift towards renewables over time.

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**Data Centers and Critical Infrastructure:** Data centers require highly reliable power, and typically

use diesel backup generators. Mainspring is positioning its linear generators as a cleaner, **fuel flexible backup** or even primary power source for data centers. In 2024 Mainspring entered a strategic partnership with **Schneider Electric**, a leader in data center power systems, to integrate 21

linear generators into Schneider’s **EcoStruxure Microgrid** solution for data centers . The idea is to enable data centers to deploy on-site generation that can run on natural gas now and transition to hydrogen later, reducing dependence on diesel and grid constraints. Members of Mainspring’s advisory board (like Google’s and Microsoft’s former data center energy leads) underscore the 24 77

interest in this technology for that sector . Hospitals and campuses that need 24/7 uptime are another use case – they can use Mainspring units for both emergency power and to shave peak loads.

As of 2022–2023, Mainspring reported **dozens of units deployed** across multiple customer sites and a backlog of orders as more organizations pilot the technology . Customers mentioned in public

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releases include **Kroger** (retail), **Lineage Logistics** (cold storage warehouses), **PG&E** and **Florida Power &** 6

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**Light** (utilities via NextEra), and various commercial real estate and industrial sites . The **NextEra Energy** $150   million contract has been a key driver, as NextEra’s distributed generation group is deploying 10 79

Mainspring generators under energy-as-a-service contracts for end customers across the U.S. . This model allows customers to host the generators and purchase power from them (rather than owning the hardware), lowering the barrier to adoption.

Looking ahead, Mainspring is developing larger-capacity versions of the linear generator to serve bigger facilities and utility-scale needs. The current 250 kW module was a starting point; higher power models (potentially in the 500 kW to multi-MW per unit range) are expected as the technology matures, especially since the linear architecture can be expanded in length or with more reaction chambers. In the meantime, the company’s focus remains on scaling manufacturing and fulfilling orders for its existing product, while supporting installations in diverse scenarios from **EV charging hubs** to **microgrid communities**.

**Team and Culture**

Mainspring Energy’s team is composed of experienced engineers, entrepreneurs, and industry experts unified by the company’s mission of enabling a resilient, low-carbon grid. The company’s leadership includes its three co-founders in top executive roles – **Shannon Miller (Chief Executive Officer)**, **Matt** 80 81

**Svrcek (Chief Technology Officer)**, and **Adam Simpson (Chief Commercial Officer)** . All three met as Stanford Ph.D. students and have led Mainspring since inception, with Miller as the public-facing CEO driving vision and partnerships. They are joined by senior executives such as **Scott Gebicke (Chief Operating Officer)**, **David DeGraaff (SVP of Engineering)**, **Ryan Fletcher (Chief Financial Officer)**, **Maria Amundson (Chief Communications Officer)**, and **Haben Goitom (General Counsel)**, among others on the 82 83

management team . This leadership group brings experience from top companies in the power sector, technology, and manufacturing, which has helped Mainspring navigate from R&D to commercial product delivery.

The **company culture** at Mainspring is often described as innovative and collaborative, grounded in a set of core values that guide how teams operate. Mainspring highlights three primary values: **Pragmatic** 84 85

**Optimism, Excellence Without Ego, and Proactive Collaboration** . “Pragmatic Optimism” reflects a balance of ambitious vision with practical problem-solving – employees are encouraged to tackle big 84

challenges in clean energy with creativity, while staying grounded and efficient in execution . “Excellence Without Ego” denotes a focus on high-quality work and technical rigor, paired with humility and continuous learning; even as Mainspring hires top talent (including Ph.D.-level engineers and experienced industry 86

professionals), a humble, customer-focused attitude is expected . “Proactive Collaboration” underscores cross-disciplinary teamwork – mechanical, electrical, and software engineers work closely together, and the company values inclusion and respect in interactions, extending to partnerships with customers and 87

external partners . These values are more than slogans – they influence hiring (Mainspring’s interviews probe for cultural fit and teamwork skills) and how projects are managed internally. For instance, the development of the linear generator required mechanical and electrical engineers to solve problems side by side, and the culture encourages that kind of integrated collaboration.

Mainspring’s workforce has grown rapidly in recent years. From a small core team in the early 2010s, the 88

company expanded to **roughly 400 employees by 2022** after its major funding rounds , and continues to hire across engineering, manufacturing, sales, and customer support functions as production scales up. Notably, Mainspring is establishing a new manufacturing facility in Pennsylvania (with government support) which is expected to create nearly 600 new jobs in the coming years, indicating the company’s transition

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into large-scale production and the accompanying talent needs. The organization structure includes not just product development and engineering, but also field service teams that commission and maintain units at customer sites, and a growing commercial team that works on project development with clients and financing partners.

To support its growth and industry reach, Mainspring has assembled a strong advisory network and governance. Its **Board of Directors** and investors include well-known figures in cleantech (e.g. investors like **Bill Gates** and firms like **Khosla Ventures**, **Shell Ventures**, **Chevron Technology Ventures**, etc. are backers) . In 2025, the company formed a **Strategic Advisory Board** specifically to bolster its

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presence in the data center and utility sectors . This advisory board features leaders such as

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**Christian Belady** (a pioneer in data center energy efficiency from Microsoft), **Joe Kava** (who led data center operations at Google), **Phyllis Currie** (former utility executive at LADWP), among others – all of whom bring deep domain expertise . Their guidance is helping Mainspring tailor its product and market

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approach to these key industries.

Mainspring’s **company culture** also emphasizes the broader mission – employees are often drawn to the company by the opportunity to work on technology that addresses climate change and grid reliability. The company frequently notes that it is **“solving essential problems”** in the energy transition and that every 94

employee’s work contributes to providing reliable, affordable, cleaner electricity . This mission-driven ethos, combined with the excitement of bringing a first-of-kind hardware product to market, has been a selling point in recruiting talent. Mainspring has been recognized in awards like **Fast Company’s innovative companies** and has a positive reputation in the cleantech community for reviving hardware innovation in an era that had seen many clean energy startups falter. The team takes pride in accomplishments such as winning the **IEEE Emerging Technology award (2024)** for its linear generator 95 96

innovation and being named to the Global Cleantech 100 list . These accolades and a sense of purpose contribute to an energetic culture aimed at growth and impact.

**Market Positioning**

Mainspring Energy has positioned its linear generator as a disruptive addition to the distributed energy market, offering capabilities that span the benefits of engines, turbines, and fuel cells while mitigating many of their drawbacks. Traditional on-site generation is dominated by **diesel and natural gas reciprocating engines** (e.g. gensets from Caterpillar, Cummins) and by smaller gas **microturbines** or emerging **fuel cell systems** (like Bloom Energy’s solid oxide fuel cells). Mainspring enters this landscape with a solution that is fuel-flexible, cleaner, and potentially more economical for many use cases. As CEO Shannon Miller puts it, the linear generator is intended to deliver “**electricity more cleanly, at a lower cost and more flexibly**” than the incumbent technologies, including multi-billion-dollar markets of turbines, 97

engines, and fuel cells . In effect, Mainspring aims to carve out a new category that can complement and eventually displace traditional generators in certain segments, especially where emissions and future fuel compatibility are critical.

**Competitive Advantages:** One of Mainspring’s key differentiators is its **ability to seamlessly switch between fossil fuels and zero-carbon fuels**. This is increasingly important as industries look to decarbonize. Competing generator manufacturers (Cummins, Wärtsilä, Mitsubishi, Siemens, GE, etc.) have announced or are developing engines and turbines capable of running on hydrogen or ammonia blends, 36 98

but those typically require specific models or retrofits for each fuel . None of those conventional products are designed to *regularly switch* between different fuels without hardware changes – they are

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usually optimized for one fuel at a time . Mainspring’s generator, by contrast, was built from the ground up to be fuel-agnostic. This means a customer can install a Mainspring unit to run on natural gas today and 35 73

be confident it can transition to hydrogen in the future, **“without having to be replaced”** or rebuilt . This future-proofing is a strong selling point for companies worried about asset longevity in the face of changing regulations or fuel availability. As Miller noted, *“Customers don’t know which fuels are going to be available when… They don’t want to buy a system and then encounter some regulatory or cost change they didn’t*

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*anticipate. This [linear generator] allows them to shift to fuels based on what’s available and low-carbon.”*

Another advantage is **emissions compliance and sustainability**. In many markets (California, for example), tightening air quality rules are making it harder to deploy traditional combustion generators due to NOx and particulate emissions. Fuel cells solve that emissions problem but are expensive and not fuel flexible. Mainspring offers a near-zero NOx profile without expensive after-treatment, which is a compelling proposition for urban areas and commercial sites that must meet strict permits . This has been

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highlighted as communities push back on diesel gen-sets; Mainspring allows reliability without pollution in 99

those contexts .

In terms of **cost and economics**, Mainspring claims that once scaled, its linear generators will have lower lifecycle cost than fuel cells and potentially competitive upfront cost with engine gensets (especially when factoring in no emissions control equipment needed for compliance). The linear generator’s high part-load efficiency and fast response also enable value stacking – e.g. one unit can do peak shaving (saving on electricity bills), provide backup power, and participate in grid services like demand response, maximizing its 100 101

economic utilization . This multi-use capability can out-compete single-use backup generators that sit idle most of the time. The partnership with NextEra to offer energy-as-a-service (leasing the generators with a power purchase agreement) further enhances the cost proposition by eliminating upfront cost for 79

customers .

**Market Trends:** Mainspring’s rise comes at a time of converging trends in the energy landscape. There is surging interest in **distributed energy resources (DERs)** and **microgrids** to improve resilience against 100 102

outages from wildfires, storms, and grid constraints . The increasing frequency of extreme weather events has made reliable backup power a priority for businesses and communities. At the same time, there is a strong push to reduce reliance on diesel due to climate and health concerns. Mainspring’s generators align with these trends by providing resilient power that can run on cleaner fuels. Another trend is the **integration of renewables and the need for firming capacity** – as solar and wind penetration grows, there is a market need for flexible generation that can fill in when the sun isn’t shining or wind isn’t blowing. The linear generator’s fast ramping and dispatchability make it a good candidate to firm local renewable generation, acting as a “glue” in hybrid systems (solar/storage/gen-set combinations) .

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Governments and regulators are also moving toward technology-neutral approaches that reward low emissions and flexibility, which could benefit Mainspring. For instance, incentive programs like California’s SGIP now support technologies using biogas or renewable fuels (which Mainspring qualifies for), and the U.S. Inflation Reduction Act of 2022 provides production credits for hydrogen usage that could indirectly help Mainspring if its customers use hydrogen fuel. In October 2024, Mainspring’s selection for a federal manufacturing grant was a signal that policy-makers see promise in this technology for domestic clean 19

energy manufacturing .

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**Competitors and Alternatives:** Mainspring is not alone in targeting the clean onsite power market, but it’s unique in its technical approach. Competing solutions include:

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**Natural Gas Engine Microgrids:** Companies like **Enchanted Rock** and **Scale Microgrid Solutions** 105

install fleets of natural gas reciprocating engines for backup power and peak shaving services . These have the advantage of maturity and low cost, but they still have notable NOx/CO₂ emissions and are generally not designed for hydrogen without engine modifications. Engine gensets also require more maintenance (oil, overhauls) and have lower efficiency at small scale compared to Mainspring’s linear generator.

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**Fuel Cells: Bloom Energy** and **FuelCell Energy** offer stationary fuel cell systems (typically 200– 106

300 kW modules) that provide ultra-clean power using natural gas or hydrogen . Fuel cells have higher electrical efficiency (~55–60% for Bloom’s solid oxide) and zero NOx. However, they require high-purity fuel (no biogas without extensive cleanup), cannot easily switch fuel types, and respond slowly to load changes. They also have high upfront costs and stack replacement costs. Mainspring is often viewed as sitting between engines and fuel cells – not as ultra-efficient as fuel cells, but much cheaper and more flexible, while being cleaner than engines. In data centers and other markets, Mainspring could directly compete with Bloom’s Energy Servers as a cleaner alternative to gensets.

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**Microturbines and Stirling Engines:** Niche technologies like **Capstone microturbines** (30–200 kW

range) and Stirling engines have been used for distributed generation. Microturbines are compact and low-emission (when using recuperation) but typically only ~30% efficient and struggle at part load. Stirling engines can run on various fuels and are clean, but they have low power density and haven’t scaled well commercially. Mainspring’s linear generator can be seen as a more robust alternative – offering higher efficiency than microturbines and more power density than Stirling engines, with fuel flexibility in both cases.

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**Emerging Linear Generator startups:** As of mid-2020s, Mainspring is the clear leader in

commercializing linear generators, but some others are exploring related concepts. For example, in 107

the transportation realm, **Hyliion** has looked at a linear generator range extender for trucks . Large engine makers have also undoubtedly researched free-piston engines historically. 43 65

Mainspring’s broad patent coverage may pose a barrier to newcomers . It’s worth noting that the linear generator concept was studied in labs (including at Sandia National Lab and by automotive companies) in the past, but Mainspring appears to be first to turn it into a viable product at commercial scale.

Given these comparisons, Mainspring’s market positioning emphasizes **flexibility and transition readiness**. The company often highlights that its product can serve current needs (e.g. reliable backup power, peak shaving at lower cost than grid) *today* with existing fuels, while being ready for *tomorrow’s* zero 73

carbon fuels – essentially providing a bridge to a decarbonized future without stranding assets . This message resonates with customers who have sustainability goals but can’t yet get pure zero-carbon energy 24/7. Additionally, by marketing the linear generator as a **“dispatchable renewable”** (when run on biogas or hydrogen produced from excess renewables), Mainspring taps into the trend of 24/7 carbon-free energy solutions (important for tech companies and others with round-the-clock clean power targets).

**Market Share and Traction:** As a still-private company, Mainspring’s exact sales figures aren’t public, but it has reported a strong pipeline. The NextEra contract ($150 million) alone implied dozens of units to be installed (possibly on the order of 100+ units). The company’s statement of “hundreds of MW in development” suggests a significant volume of orders/options, though some of those may be future 25

commitments . Mainspring’s approach to market has been to partner with established players (e.g. 108 109

NextEra, Schneider, and resellers like **Kinsley Energy Systems** in the generator distribution space ) 10

to reach customers. This is a practical strategy to penetrate a market that typically relies on trusted generator OEMs and engineering firms. If Mainspring continues to execute and if field deployments demonstrate reliability at scale, the company could start capturing a notable share of the backup power and distributed generation market, especially in regions with strict emissions rules or high renewable penetrations.

In summary, Mainspring Energy is positioning itself not just as a generator manufacturer, but as an **enabler of the modern grid**: providing local generation that is *clean, flexible, and future-ready*. Their linear generator stands at an intersection of multiple trends (resilience, decarbonization, decentralization), which, if the technology performs as promised, gives the company a chance to be a key player in the evolving energy ecosystem.

**News and Updates**

Recent developments and news about Mainspring Energy underscore its rapid progress and industry momentum in the past few years:

**Major Funding Rounds:** Mainspring has attracted substantial investment to fuel its growth. In •

**September 2022**, the company closed its **Series E funding at $290 million**, one of the largest 110

financings for a distributed energy hardware startup . This round was led by Lightrock and included strategic investors like **Princeville Capital** (whose Limited Partners include industry players) and **Chevron Technology Ventures**, among others . In **April 2025**, Mainspring

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announced a **$258 million Series F financing**, joined by investors such as **Amazon’s Climate Pledge** 111 15

**Fund, Temasek, and DCVC**, and bringing on energy industry veterans to its board . These investments pushed Mainspring’s total funding over $600   million and are being used to scale manufacturing, expand deployments, and accelerate product development.

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**Manufacturing Expansion:** In **October 2024**, Mainspring was awarded an **$87 million grant from**

**the U.S. Department of Energy** to establish a new manufacturing facility for linear generators in 19

Allegheny County, Pennsylvania . This grant – part of a federal effort to onshore clean energy manufacturing – will support a large-scale production line and is expected to create hundreds of jobs. Pennsylvania’s state government also provided incentives to attract Mainspring’s expansion, highlighting the economic development aspect of the clean tech industry. The new factory will significantly increase Mainspring’s production capacity beyond its initial Menlo Park pilot manufacturing line, enabling the company to fulfill its growing order backlog.

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**Strategic Partnerships:** Mainspring has entered partnerships to extend its market reach. A notable collaboration is with **Schneider Electric** (announced March 2024), where Schneider will integrate Mainspring’s fuel-flexible linear generators into its microgrid offerings for commercial and industrial customers . Schneider, a global leader in energy management and backup power systems,

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provides an established channel to data centers, hospitals, and other critical facilities, lending credibility and integration expertise to Mainspring’s solution. Mainspring also launched a **reseller program in mid-2024**, signing up a network of distributed energy providers and engineering, procurement & construction (EPC) firms (e.g., **Kinsley Energy Solutions, ABM, and others**) to sell and install its generators across different regions . This channel strategy accelerates

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deployments by leveraging partners’ local presence and customer relationships. Furthermore, Mainspring has ongoing strategic investor relationships with utilities like **American Electric Power**

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**(AEP)** and **NextEra Energy** that not only invested but also pilot the technology in their operations

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**Notable Deployments:** Several high-profile deployments have been publicized, demonstrating the

versatility of Mainspring’s generators. In **May 2024**, it was announced that **Mainspring units are powering the nation’s largest electric truck charging depot**, a facility in Los Angeles operated by Prologis for Maersk’s fleet of electric trucks . This project is a landmark for heavy-duty

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transportation electrification and showcases how onsite generation can enable new, large electricity loads (charging dozens of trucks) without waiting for grid upgrades. In **September 2024**, Mainspring revealed an agreement to deploy generators at **five facilities of Lineage Logistics** in Texas .

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Lineage, a global cold-chain storage company, will use the linear generators to provide reliable, cost effective power (especially during peak grid periods) and to maintain backup power for refrigerated warehouses – an application where both resilience and fuel flexibility (potentially using biogas from food waste in the future) are attractive. Earlier, in late 2022, Mainspring announced its first **100% landfill biogas pilot** with Yolo County, proving the generator’s ability to run on waste-derived fuel and eliminate flaring of methane . And one of the first utility adoptions was by **PG&E** in 2021,

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where a Mainspring generator now supports a wildfire-prone distribution node, reducing the use of diesel during grid outages . These case studies in different sectors (transportation, cold

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storage, waste-to-energy, utility microgrid) illustrate the broad potential market for the technology.

**Awards and Recognition:** Mainspring’s innovations have garnered industry accolades. In **April**

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**2023**, **BloombergNEF** named Mainspring one of its **BNEF Pioneers**, specifically recognizing the company for “Accelerating the Deployment of Clean Hydrogen” – an acknowledgement of 18

Mainspring’s ability to use hydrogen/ammonia fuels in its generators . Mainspring was also listed in the **Global Cleantech 100** and featured by the **World Economic Forum** as an innovator in the Energy Transition (as part of WEF’s initiative on cleantech startups) . In 2024, **Fast Company**

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honored Mainspring in its Innovative Companies rankings (energy category), and the **IEEE** awarded 114

Mainspring an **Emerging Technology Award** for the development of the linear generator . Such recognition from independent experts and media provides validation and raises Mainspring’s profile among customers, investors, and prospective hires. It signals that the company is viewed as a leading innovator tackling the challenge of clean, reliable power – which aligns with the needs of a modern grid.

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**Advisory Board Formation:** In **August 2025**, Mainspring announced the formation of a **Strategic** 91

**Advisory Board** to support its growth in key markets . This board’s members include heavy hitters from the data center industry (e.g., **Christian Belady**, who designed Microsoft’s data center energy strategy, and **Joe Kava**, who led Google’s data center operations) as well as utility sector 93 77

leaders (such as former executives from NextEra and large public utilities) . Their role is to advise Mainspring’s leadership on product roadmaps, market entry strategies, and partnerships in their respective domains. The creation of this board indicates Mainspring’s focus on tailoring its solutions to the needs of **data centers** (which prize reliability and sustainability) and **utilities** (which require grid-friendly, scalable solutions) – two critical adoption arenas for the technology. It also reflects the company’s increasing maturity, as it seeks guidance to navigate regulatory, operational, and scaling challenges.

In conclusion, Mainspring Energy has rapidly evolved from a research project into a commercial contender in the energy sector. Its linear generator technology is gaining real-world traction through a series of

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deployments and partnerships, backed by strong financing and a growing support ecosystem. As the world’s energy systems transition to more distributed and cleaner models, Mainspring’s progress will be closely watched. The company’s recent news – from technical achievements (like running on 100% ammonia) to strategic deals (like the NextEra contract and Schneider partnership) – all point to its ambition to become a **major player in distributed, dispatchable clean generation**. If Mainspring continues on its current trajectory, it could play a significant role in how businesses and utilities approach reliable, flexible power generation in the years ahead, providing a key tool for both decarbonization and resiliency in the

electric grid.