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California Energy Commission
Docket Unit, MS-4
Docket No. 21-ESR-01
715 P Street
Sacramento, CA 95814

Re: Docket 21-ESR-01: Resource Planning and Reliability – Mainspring Comments on Draft SB 423 Emerging Renewable and Firm Zero-Carbon Resources Report, Publication Number CEC-200-2024-012-D.

Dear Vice Chair Gunda and CEC staff:

Mainspring Energy (Mainspring) appreciates the California Energy Commission (CEC) and staff's efforts in preparing the Draft SB 423 Emerging Renewable and Firm Zero-Carbon Resources Report (Report). Mainspring agrees with the Report's overall findings, in particular, that Mainspring's Linear Generator, when using clean, renewable fuels, can operate as a firm zero-carbon resource that is reliable, provides system reliability, and will help California transition to a zero-carbon electrical grid, as required by Senate Bill (SB) 423.

Mainspring's technology is fully commercialized running on natural gas and renewable natural gas (RNG)/biogas. Our next objective is to fully commercialize utilizing hydrogen for generation and in long-duration energy storage (LDES) applications, which are critical to provide flexible, grid balancing and reliability services. California solicitations and procurements are essential steps to bring this vision to reality.

While much of the information in the Report was timely several years ago, Mainspring finds that the Report's analysis of Mainspring's Linear Generators is now dated and does not represent the current status and commercial availability of and the benefits provided by Mainspring's Linear Generators. The purpose of these comments is to provide up-to-date information for incorporation into the final Report. With this new information on linear generator technology, which can be used in a variety of applications, we also offer updates to the Report's discussion of the status and recommendations on hydrogen, RNG/biogas and LDES.

I. The Technology Maturity of Mainspring's Linear Generators Should Be Updated.

The Report describes linear generators as "[n]on-combustion and non-fuel cell (NCNFC) gas fueled generators" that "convert motion along an axis into electricity, achieved through the compression of a fuel and air mixture until the mixture reacts without any combustion necessary." The Report correctly notes that the "low-temperature nature of this technology minimizes NOx emissions" and that a linear generator can adjust "compression and expansion based on fuel type and quality so it can operate with a variety of fuels, including 100% hydrogen."[1] Finally, the Report assigns a "technology readiness level" (TRL) of 7[2] to NCNFCs based on a determination that:

> [n]on-combustion non-fuel-cell (NCNFC) generators are progressing into the pilot and demonstration stage of development with example projects in Menlo Park and Angwin, leading to a TRL score of 7.[3]

To update the assessment, Mainspring's Linear Generators now have over 1,000 hours of 100% hydrogen-fueled operation. TRL 8 requires in-the-field commercial operations, which would be possible with financial support to make software improvements and procurements for off-take. While the ability to run on 100% hydrogen is critical to meeting decarbonization goals, there may be instances where hydrogen becomes unavailable or green ammonia or another clean electrolytic fuel becomes more cost-effective. Mainspring's Linear Generators can run on any gaseous fuel interchangeably without hardware changes. Mainspring also has the ability to run on blends or pure incumbent hydrocarbons (natural gas and propane) in case of an emergency, adding to its local and system reliability.

The development of Mainspring's Linear Generators has progressed well beyond the "pilot and demonstration" stage and is fully developed and commercially available. In fact, Mainspring has deployed tens of megawatts of linear generators, including across California, in the last four years, primarily in behind-the-meter commercial applications. The company also has a pipeline of front-of-the-meter grid-scale projects that are not yet public which will all be capable of running 100% on hydrogen without hardware changes.

> The company has seen significant adoption from customers such as dairy farms and landfills, which are able to capture waste methane from their processes and use it to fuel the generator. Mainspring has already participated in the construction of microgrids to support electric vehicle (EV) charging stations at logistics centers, and expects to see significant growth from data centers in the coming years. [4]

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[1] Report, p. 26.

[2] Ibid.

[3] Report, p. G-6.

[4] See https://www.utilitydive.com/news/schneider-electric-mainspring-energy-linear-generator-microgrid/711941/.

Most recently, Mainspring's Linear Generators are being integrated into Schneider Electric's microgrid systems offerings.[5]

> As the energy sector seeks to decarbonize operations and protect power resilience amidst increasing extreme weather events and grid demands, this innovative energy solution allows customers to efficiently generate electricity onsite and operate in parallel to the power grid, or independently from the grid when needed. For facilities such as data centers or healthcare facilities, the decentralization of power offered by the new Schneider Electric-Mainspring Microgrid Solution ensures accessible electricity to power critical operations and reduce greenhouse gas emissions. The novel fuel-flexibility of the Mainspring generator also allows customers to dynamically switch among multiple fuel options, including low- and zero-carbon fuels, without retrofit.[6]

Further, Mainspring's Linear Generators currently are powering projects throughout California, for a variety of purposes. For example, Mainspring's Linear Generators are providing 2.75 MW of dispatchable power to a heavy-duty truck EV charging depot that Prologis and Maersk built to serve the Ports of Los Angeles and Long Beach.[7] Mainspring's Linear Generators are also providing power to dairy digesters, wastewater treatment facilities, grocery stores, and they are being used by municipal utilities to support reliability needs and renewable firming at utility-scale.[8]

In light of the deployment level to date, we recommend that the CEC revise the Report to acknowledge that Mainspring's Linear Generators are commercially available and in use. As noted in our December 1, 2023 comments in this docket (21-ESR-01), linear generators can be configured to run on hydrogen, RNG, and biogas without major equipment changes or reconfiguration. The primary barrier to running linear generators on alternative fuels is the availability of the fuel itself, not the availability or scalability of linear generators. The availability of cost-effective hydrogen, financial offtake, and relatively small technology improvements to software would drive the technology running on hydrogen to a TRL value of 9.

II. The Report's Discussion of The Current Size of Mainspring's Linear Generators Is Outdated and Should Be Revised.

The Draft Report states that:

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[5] See https://www.prnewswire.com/news-releases/schneider-electric-and-mainspring-partner-to-offer-groundbreaking-fuel-flexible-microgrid-solution-302094475.html.

[6] Ibid.

[7] See https://www.microgridknowledge.com/energy-storage-microgrid/article/55042968/prologis-and-performance-team-launch-new-ev-charging-depot-powered-by-ev-truck-microgrid-near-ports-of-los-angeles-and-long-beach.

[8] See https://www.mainspringenergy.com/solutions/#specs.

> [c]urrently Mainspring's linear generator base package offers 230-kW capacity . . .. The company is currently developing a more energy-dense unit that offers 1.5 MW . . . which would likely enable larger-scale projects.[9]

However, the Report is referring to Mainspring's first commercial product, installed in June 2020.[10] Since then, Mainspring has increased its standard linear generator unit to 250 kW capacity and is designing and marketing large-scale projects that exceed 100 MW.[11] The Report incorrectly states the sizing up to 25 MW, but there is no upper limit on the size of linear generator installations. Mainspring's technology fits in a shipping container and is scalable to whatever size is necessary, much like a battery energy storage system.

III. The Report's Discussion of Barriers to Mainspring's Linear Generators Is Outdated And Should Be Revised.

The Report also describes "key barriers" for firm zero-carbon resources, including NCNFCs, noting, in particular, the

> [E]levated costs relative to existing alternatives, thereby limiting competitiveness and investment appeal. Additionally, concerns related to supply chain limitations and feedstock and fuel availability contribute to heightened project risks and extended timelines. Public perception challenges, infrastructure dependencies, and specific siting requirements further compound the intricacies of technology integration.[12]

However, Mainspring's Linear Generators have overcome these barriers and should be recognized as providing "broad benefits to the electric system and California's climate goals."[13] For example, the use of Mainspring's Linear Generators in Prologis-Maersk's heavy-duty EV truck charging depot is expected to annually eliminate "6,000-13,000 metric tons of CO_2 emissions" and provide the following benefits:

> **Rapid power**
> Reduced time for new power from nearly 36 months to 9 months.
>
> **Increased resilience**
> Eliminated outage risk with an islanded microgrid, reducing risk to fleet availability.

[9] Report, p. G-6.

[10] See https://spectrum.ieee.org/mainspring-energy.

[11] See https://www.mainspringenergy.com/solutions/#specs.

[12] Report, pp. 51-55.

[13] Report, p. 55.

Cost savings

Obtained best-in-class total cost of ownership resulting from competitive cost of capital and low operating expenses.

Hydrogen-ready

Ability to run biogas and zero-carbon fuels like hydrogen.[14]

Another important benefit of Mainspring's Linear Generators, though not discussed in the Report, is, as Prologis described, the ability to "speed up project completion time, rather than waiting up to two years for the required grid upgrades" and to "build a microgrid onsite that can either be grid-connected or operate independently of the local grid.[15] Linear generators can also alleviate interconnection challenges through co-location at substations to provide reliability services when conventional transmission upgrades are not available or will take too long.

Unlike many of the other technologies discussed in the Report, Mainspring's Linear Generators are not limited to specific sites, specific fuel sources, or by the availability of grid interconnections or capacity. The Report should be revised to note this distinction and the benefits provided by Mainspring's commercially ready and scalable linear generators.

IV. The Report's Discussion of RNG Is Overly Narrow And Should Be Revised to Include Biogas Power Generation.

The Report focuses on the availability and technological maturity of fuels without sufficiently acknowledging the range of fuels and generation technologies that convert biomass to useful energy. The Report's section title is misleading as "Renewable Natural Gas (RNG)," as the section includes robust, but inconsistent discussion of biogas, as well. As a result, we recommend the section and appendix titles be changed to "Renewable Natural Gas and Biogas" and make additional changes discussed in this section.

The Report generally defines RNG as gas produced from biogas or syngas to have a regulated level of over 90% concentration of methane. On the other hand, biogas, which is an intermediary and can be used directly for power generation also, has a heavier content of carbon dioxide, water, hydrogen sulfide, and other gases.[16]

Biogas is given inconsistent attention in the Report relative to its technological maturity. For instance, "Current Deployments" indicates there are "about 100 operational livestock anaerobic digesters with another 40 in construction…(and) 54 operational landfill gas projects" in California.[17] Many of these projects are producing power directly via biogas (or could be), and that should be highlighted. Table 43 highlights the TRL of fuels but calls these "RNG

[14] See https://cdn.sanity.io/files/m8z36hin/production/9e0d45d34d16aab1f12bc168816db7818df63549.pdf.

[15] See https://www.microgridknowledge.com/energy-storage-microgrid/article/55042968/prologis-and-performance-team-launch-new-ev-charging-depot-powered-by-ev-truck-microgrid-near-ports-of-los-angeles-and-long-beach.

[16] Report, p. F-2.

[17] Report, p. F-3.

Production" technologies, without recognizing that these fuels can be used for power generation directly as biogas. We suggest that the Table be re-named.

Likewise, the images in this section are misleading, suggesting that the most mature and plentiful technology is RNG to pipeline for combustion at natural gas combined cycle (NGCC) plants. "Figure 2: RNG Firm Zero-Carbon Resource Lifecycle for Power Generation" describes a process from gas production, upgrade to RNG, pipeline transport and finally, to existing NGCC power plants. However, RNG pipelines to NGCC are only one of many paths for converting biofuels from biomass and waste feedstocks to electricity. Mainspring's experience is that the physical properties of biofuels make consumption as biogas onsite favorable. As a result, distributed, smaller electric generation projects are often feasible, whereas upgrading the fuel to RNG for sale onto a pipeline is unnecessary and cost-prohibitive. Many of these realities are discussed in the Report's Recommendations section under "Economic Viability and Competitiveness," which underscore the importance of biogas as a resource to be valued in California (not just RNG).[18] The Recommendations should be updated to note that policies to support distribution biogas production and electric generation should be supported.

To reflect the alternative pathways for biomass into energy, and commercial viability of biogas, Figure 2 should instead be titled "RNG and Biogas." In that figure, "Upgrade to RNG" should read "Upgrade to useful fuel," and indicate a separate path after "Biogas/landfill gas" immediately to "power generation." Mainspring's Linear Generator is already commercially deployed and at a TRL of 9 on biogas for power generation at wastewater treatment plants and dairies and with plans to deploy at landfills.[19] In these cases, power is generated from 100% biogas, which is recognized in California as a negative carbon fuel.

Finally, not all generation technologies are capable of running on biogas, as the fuel can have a relatively lower methane content compared to traditional natural gas. The Report highlights this phenomenon on page 20. Linear generators have been widely accepted in part for their ability to run on relatively unrefined fuel, which makes for lower total cost of ownership. If NGCC power plants are explicitly noted here, we also request noting other technologies capable of power generation on RNG and biogas, such as the linear generator.

V. The Report's Discussion of LDES Should Compare Clean, Electrolytic Fuels to Other Forms of Storage.

The Report acknowledges that fuels can be used as a source of LDES but then only addresses electrochemical, mechanical, and thermal technologies. A thorough comparison of technologies should include clean, electrolytic fuels. The CEC has begun to recognize this

[18] Report, p. F-8.

[19] See https://cdn.sanity.io/files/m8z36hin/production/8f3b9ce98d7ec7de769a3643940a9321efe96598.pdf.

category of LDES in its recent "Assessing the Value of Long-Duration Energy Storage in California" Report (see Table 1).[20]

Continuing this inclusion would aid in the review and comparison across LDES characteristics. For instance, this Report notes that siting is a limitation for some storage systems and recommends, "(t)echnologies need to be developed to become more modular, compact and flexible, so siting becomes less of a constraint."[21] Linear generators are highly modular, compact and flexible, which should be recognized in this review of available technologies.

Another recommendation is for longer duration systems to be developed beyond 100 hours.[22] This would be a natural place to note that electrolytic fuels have the ability today to store fuel for longer than 100 hours.

In another recommendation area, "Manufacturing," the Report highlights that some forms of storage require special minerals and materials that face supply chain vulnerabilities and limitations. Linear generators generally do not face the same set of limitations.[23]

Finally, in terms of interconnection and energy markets, the Report makes important recommendations that accelerating interconnection and new market rules are important to incentivize such systems.[24] Mainspring's experience is that projects sited on the distribution system and behind customer meters, can often be studied for interconnection in less than one year, whereas public data indicates utility-scale grid projects can take 3-5 years or longer. To meet the State's climate goals it will be critical to incentivize LDES to come online quickly and where it adds the most reliability.

With the growth of data centers in California that are most commonly known to have high capacity, flat loads, locating long-duration storage behind a customer meter could make economic sense for ratepayers and individual customers alike. Such projects can also avoid the need for expensive distribution and transmission upgrades that are often shared among customers. We suggest that the final Report make a recommendation for not just co-locating LDES with solar and wind generation, but also explore co-locating with local, growing loads. This may involve new compensation and rate design structures.

VI. Conclusion

SB 423 directed the CEC to:

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[20] Go, Roderick, Jessie Knapstein, Sam Kramer, Amber Mahone, Arne Olson, Nick Schlag, John Stevens, Karl Walter, and Mengyao Yuan. 2024. Assessing the Value of Long-Duration Energy Storage in California. California Energy Commission. Publication Number: CEC-500-24-003. See p. 5. Available at: https://www.energy.ca.gov/sites/default/files/2024-01/CEC-500-2024-003.pdf.

[21] Report, p. C-9.

[22] Ibid.

[23] Ibid.

[24] Ibid.

> Identify all available, commercially feasible and near-commercially feasible firm zero-carbon resources that could support a clean, reliable, and resilient electrical grid, and distinguish which resources are capable of addressing system reliability needs and local reliability needs, with an emphasis on reducing the emissions of greenhouse gases, toxic air contaminants, and criteria air pollutants.[25]

Linear generators are available, commercially feasible, firm, zero-carbon resources that already are addressing system and local reliability needs and helping to reduce greenhouse gases, toxic air contaminants and criteria air pollutants.[26] In hydrogen and long-duration energy storage applications the technology is near commercial deployment. As currently drafted, the Report does not fully or accurately describe linear generators and satisfy SB 423's requirements. Mainspring respectfully requests that the Report be revised to include current data about Mainspring's Linear Generators and the benefits provided by NCNFCs.

Respectfully submitted,

/s/ Brian Kauffman

Brian Kauffman
Director, Wholesale Market Development

[25] Pub. Res. Code § 25216.7(b)(1).

[26] See https://spectrum.ieee.org/mainspring-energy. "The linear generator can quickly switch between different types of green (and not-so-green, if need be) fuel, including biogas, ammonia, and hydrogen. It has the potential to make the decarbonized power system available, reliable, and resilient against the vagaries of weather and of fuel supplies. And it's not a fantasy; it's been developed, tested, and deployed commercially."