

# **On-Site Power with a Linear Generator**

## **Distributed Energy Resource Technology**

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Question asked the Audience at the Opening Session  
at AEE World in Orlando a few months ago

## What is of Most Importance to Your Company?

### CO2 Emissions Reduction



Reducing the CO2 Emissions from  
Your Operation

### Resiliency



Prepare against grid outages and  
extreme events

### Energy Costs



Ensure reasonable power supply  
costs on our way to net zero

# Full solution offering for onsite power generation

## Product

**Scalable** - 230 kW per box, multiple boxes to meet any load

**Fuel flexible** - natural gas, biogas, hydrogen

**Resilient** - grid parallel and islanded operation

**Near-zero emissions** - permittable anywhere

**Easy installation** - UL listed product and grid-tie inverters

## Services

**O&M services** - 24/7 monitoring, all inclusive service

**Financing** - zero-money down, offered from Third parties

**EPC services** - design, construction, and commissioning

**Fuel supply support** - sourcing through preferred partners



# Ultimate flexibility in power generation



## Any Fuel

Software control of every reaction means seamless change from hydrogen, ammonia, RNG, natural gas, propane, and others

## Any Scale

Scalable from behind-the-meter applications to grid-connected utility projects

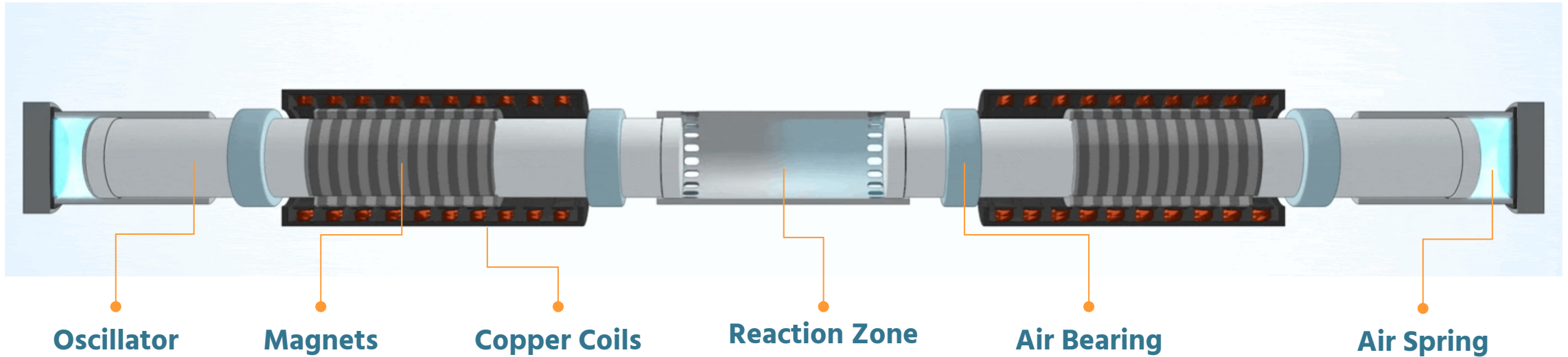
## Any Time

Firms the grid with fast-ramping, dispatchable power to compensate for increasing levels of weather dependent resources

## Anywhere

Mobile and modular.  
Easy to permit, install, and interconnect.

# Software drives core flexibility and performance



**Dispatchable**

**Fuel Flexible**

**Ultra-Low Emissions**

**High Efficiency**

**Low Maintenance**

**High Reliability**

Video: [mainspringenergy.com/technology/](https://mainspringenergy.com/technology/)

# Linear Generator Specifications

## Performance Specifications

<b>Outputs<sup>1,2</sup></b>	Power (net AC) Electrical	230 kW 480 V, 3 Phase, 60 Hz
<b>Inputs<sup>3</sup></b>	Fuels  Input Pressure Water Consumption	Natural Gas or Biogas with Hydrogen blend up to 30% 8-25 psig (15 psig nominal) None
<b>Efficiency<sup>4</sup></b>	Electrical (LHV, net AC) Heat Rate (HHV, net AC)	45% 8,416 BTU/kWh
<b>Emissions<sup>5</sup></b>	NO <sub>x</sub> Noise	< 2.5 ppm (<0.07 lb/MWh) < 70 dBA @ 6 feet
<b>Physical</b>	Weight Dimensions (L x W x H)	20 tons 20.5' x 8.5' x 9.5'

<b>Environment</b>	Temperature Range Humidity	-20 to 50 C 0 to 100%
<b>Grid-Parallel</b>	Load Tracking Power Output Range	20 kW/second up/down 0 to 100% power output
<b>Backup<sup>6</sup></b>	Grid Parallel to Island Transfer Maximum Step Load Building Soft Start Capability	< 10 sec 120% nameplate kVA Yes
<b>Other</b>	<ul style="list-style-type: none"> <li>• UL 2200 package</li> <li>• UL 1741 SA grid-tie inverter</li> </ul>	<ul style="list-style-type: none"> <li>• Remote monitoring</li> <li>• Secure customer portal</li> </ul>

<sup>1</sup> Projects greater than 1.5 MW can be optimally designed with the use of external inverters.

<sup>2</sup> Rated capacity is reduced by 10 kW if operated in the South Coast AQMD..

<sup>3</sup> 100% hydrogen and 100% ammonia capable with field UL certification.

<sup>4</sup> Measured according to ASME PTC 50 at 15 C and 1 atm.

<sup>5</sup> Products comply with emissions limits in South Coast AQMD.

<sup>6</sup> Performance with purchase of internal backup kit and additional site relays and controls equipment.

All data is subject to technical development and modification. R30023

Note 1: Mainspring is working towards increasing the generators power density though developing larger base unit nameplate ratings and overall larger system sizes.

# Technology Comparisons

# Mainspring's competitive advantage

In 2024  
Linear generators  
qualify for 30% ITC

	Linear Generators	Hydrogen Fuel Cells	Natural Gas Fuel Cells	Microturbines	Engines
<b>Low Lifecycle Cost</b>	✓				
Low CAPEX	✓			✓	✓
Low OPEX	✓				
High Electric Efficiency	✓	✓	✓		
<b>Low Emissions</b>	✓	✓	✓		
<b>Dispatchable</b>	✓	~		✓	✓
<b>Fuel Flexible</b>	✓			~	~

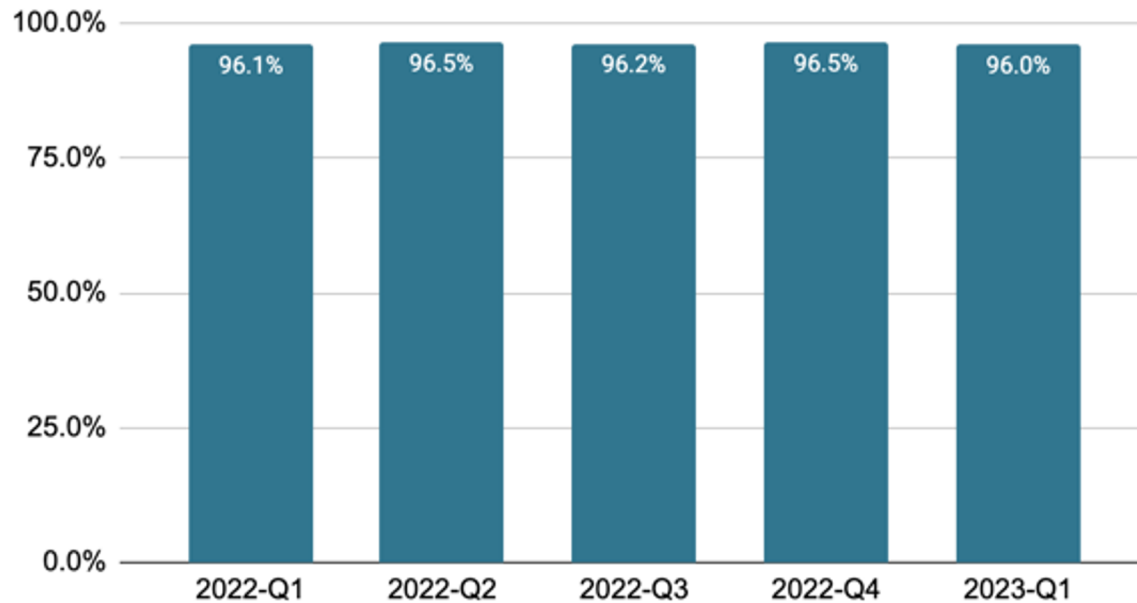
# Distributed generation by the numbers

	<b>Linear Generators</b>	Hydrogen Fuel Cells (PEM/MCFC)	Natural Gas Fuel Cells (SOFC)	Natural Gas Microturbines	Natural Gas Engines
<b>Power (kW, net AC)</b>	230 kW	200-1,000 kW	330 kW	200-1,000 kW	300-1,500 kW
<b>Efficiency (LHV, net AC)</b>	45%	40-50%	50-55%	28-30%	32-40%
<b>Fuels</b>	Natural Gas, Biogas, Hydrogen	Hydrogen (99.99% purity)	Natural Gas, Biogas	Natural Gas, Biogas	Natural Gas, Biogas
<b>Output Range</b>	0-100%	20-100%	90-100%	30-100%	50-100%
<b>Start Time</b>	< 10 sec	< 5 min	> 3 hours	< 30 sec	< 20 sec
<b>NOx Emissions (lb/MWh)</b>	< 0.07	~ 0	< 0.02	< 0.41	< 3
<b>CO2e Emissions (lb/MWh)</b>	1,035 (natural gas) 0 (hydrogen)	0	805 - 885	1,475 - 1,580	1,105 - 1,380

# Operations and O&M

# World class reliability metrics

## Mainspring fleet availability (EAF\*)<sup>1</sup>



Availability across all customer sites: **96.3%**

Unplanned Outages: **2.3%**

Planned Outages: **1.4%**

Benchmarks<sup>2</sup>

Natural gas gensets: 92-95%

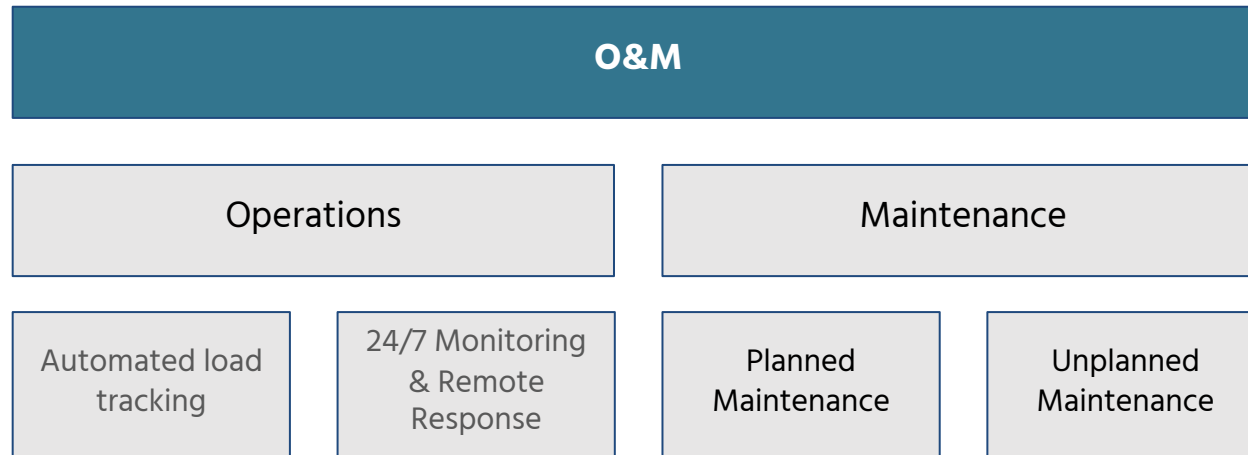
Microturbines: lower than engines and reduces further with frequent starts/stops

1 EAF\*: NERC's Equivalent Availability Factor, when the building needs power.

2 Benchmark natural gas and microturbine availability factor provided through Mainspring interviews with several industry experts.

# O&M overview

## Breakdown of O&M activities



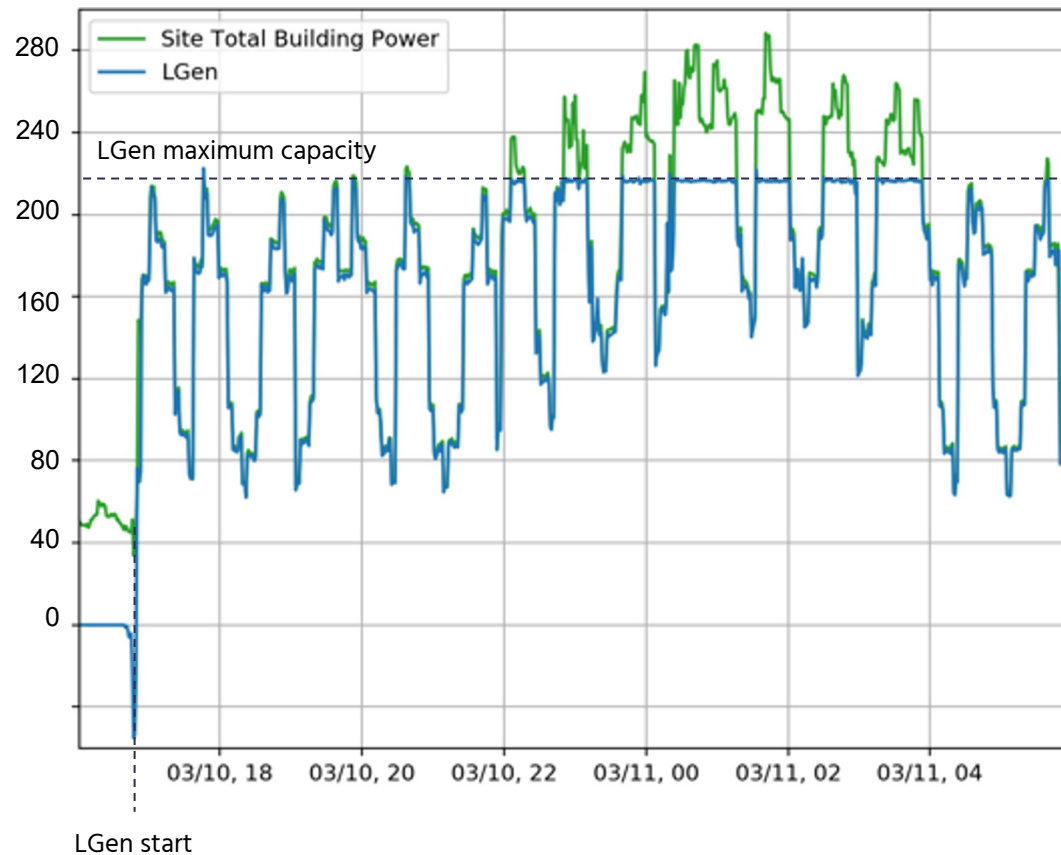
Mainspring units track load automatically through onsite controllers that can be programmed in a variety of ways.

Our operations team monitors Mainspring's units on a 24/7 basis and is able to respond remotely to 90% of issues that may arise during operations.

The most frequent planned maintenance events are the replacement of the cylinder seals and air filters, which are consumables (similar to oil and air filters for gas engines).

# Automated load tracking

## Example of Mainspring unit load tracking



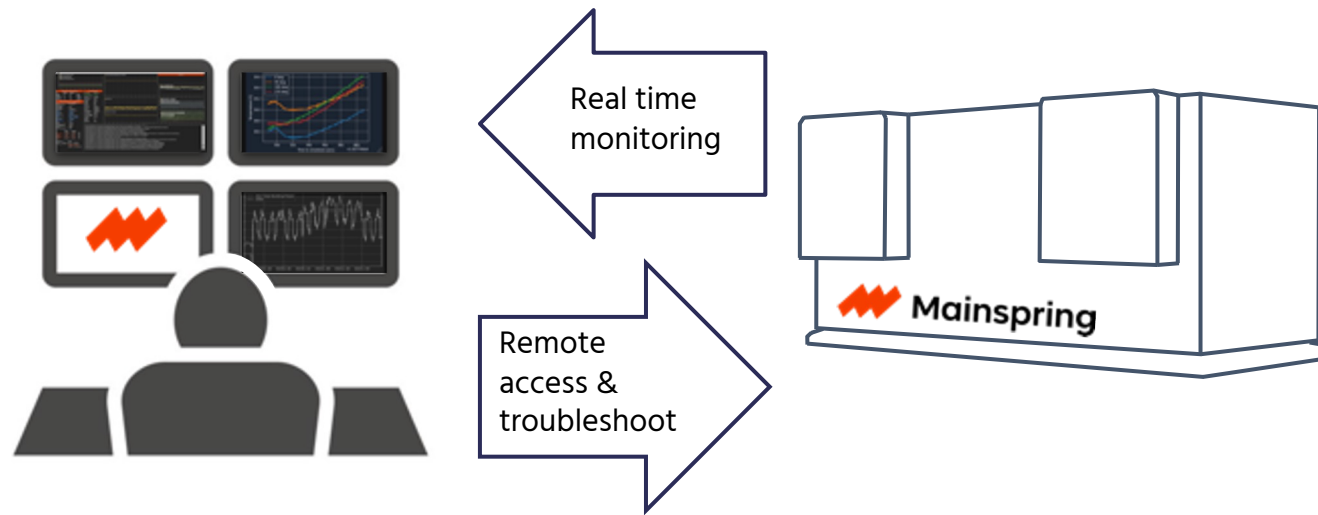
Mainspring units track load automatically through onsite controllers that can be programmed in a variety of ways.

The example to the left shows the reliable load tracking performed on a building's load over a period of ten hours.

When a solar installation is present, Mainspring units are able to track the residual load after solar following both the variations in building load and solar production.

# 24/7/365 monitoring & remote response

## Mainspring's Fleet Operations control room



Mainspring's Fleet Analytics team is continuously monitoring the generators in the field 24/7/365.

The interface collects data in real-time from the units, providing real-time alerts, including system notifications and phone/ text/ email escalation.

Our fleet operations team can remotely troubleshoot issues, either proactively or reactively.

# Linear Generator Case Studies

# Customer challenges we most typically address

## Cost Savings

*Driving Economic Value*

- Lower energy costs
- Increase predictability and control
- Reduce exposure to utility rate risk



[\[case study\]](#)

## Emissions & Carbon

*Achieving Sustainability Goals*

- Lower carbon emissions
- Reduce or eliminate carbon and NOx emissions
- Increase compliance control and predictability



[\[case study\]](#)

## Resilience

*Maintaining Business Operations*

- Reduce business impacts due to grid outages
- Reduce inventory or productivity losses
- Resilience with revenue generation



[\[case study\]](#)

## Speed

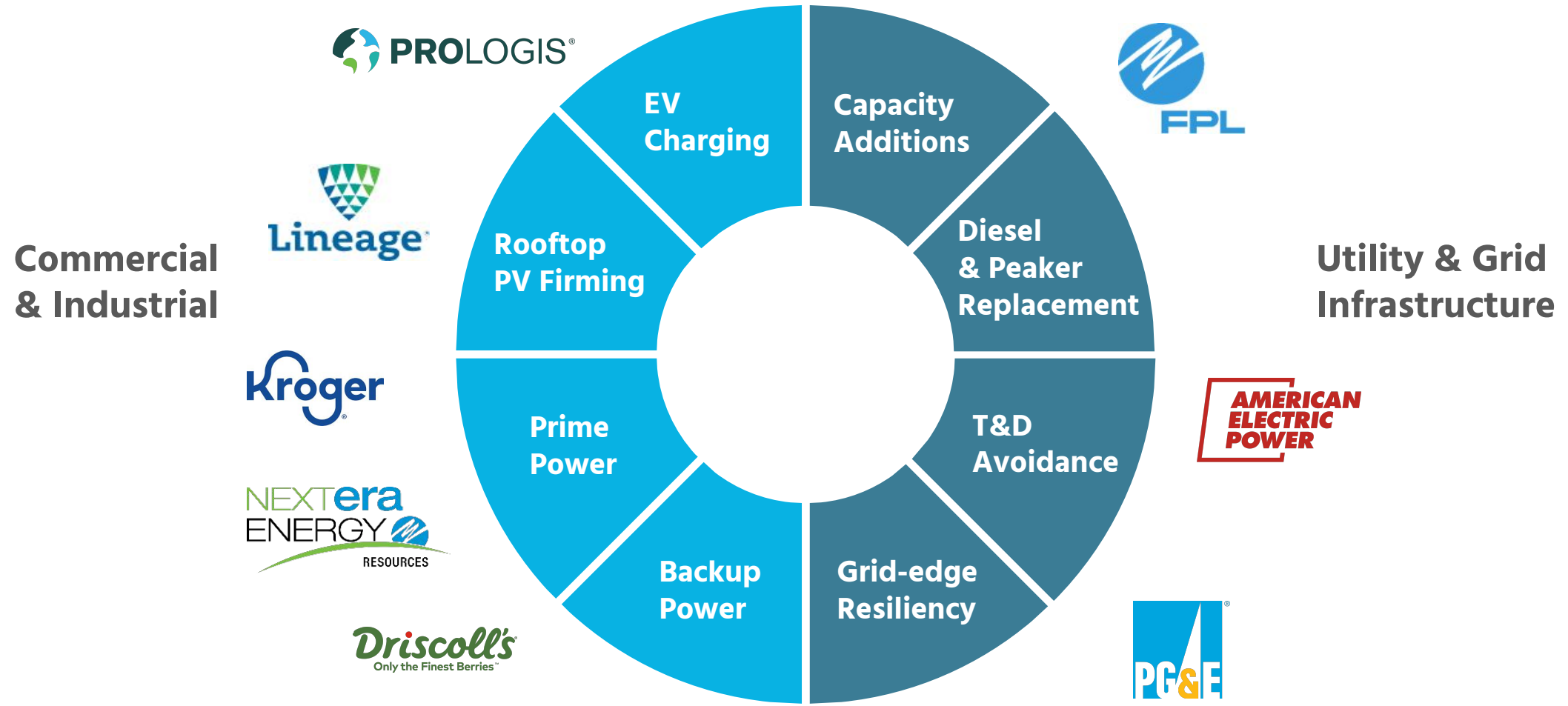
*Powering Sites Faster than Utility*

- Faster power than waiting on utility upgrades
- Clean resilience following utility interconnection
- Fuel flexibility to meet cost & sustainability goals



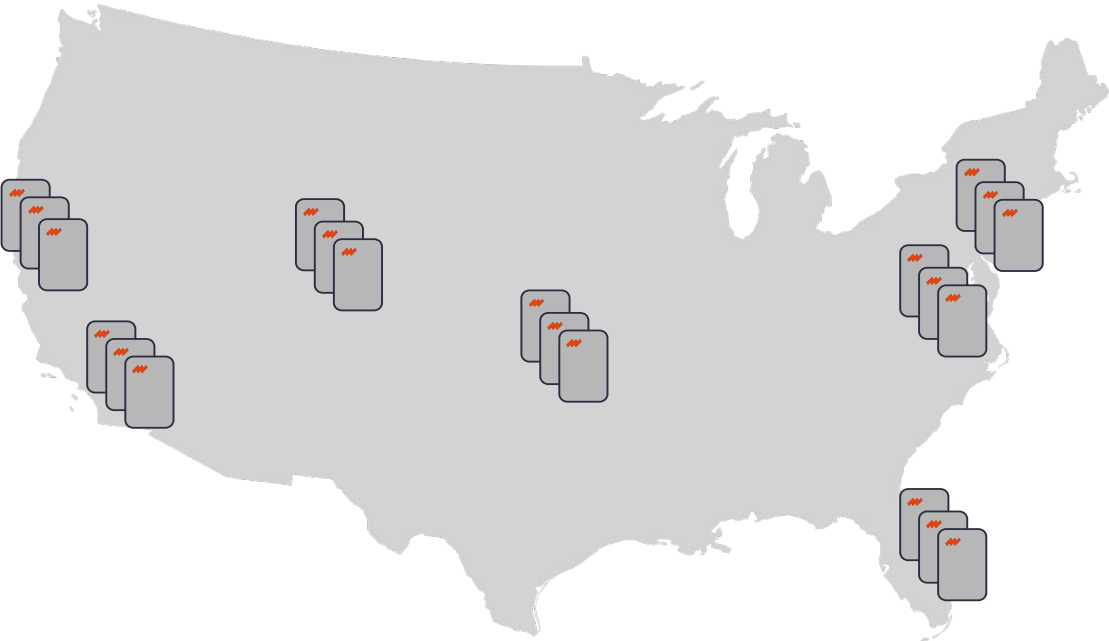
[\[case study\]](#)

# Clean firm power for a broad range of needs



# Proven commercial results for top-tier customers

## Rapidly Expanding Nationwide Footprint



## In-Field Power Generation Experience

- 20+ Years Core Run Time
- 3+ Years Customer Operation
- Availability Beats Industry Averages



# Select Mainspring Customer Case Studies

## Predictable and lower energy costs



- **Problem:** Tight profit margins, utility price volatility
- **Solution:** Deploy LGen for prime power, NEER financing
- **Impact:** \$1M+ savings per store over the lifecycle

## Clean on-site power generation paired with solar



- **Problem:** Desire to reduce grid dependence
- **Solution:** Two LGen paired with 3.3MW rooftop solar
- **Impact:** Cost savings + carbon reduction + resilience

## Biogas power generation and resilience



- **Problem:** Reduce cost and increase resilience
- **Solution:** Increase biogas production; convert to power
- **Impact:** Higher facility reliability; lower GHG emissions

## Speed-to-power for EV charging infrastructure



- **Problem:** Rapidly deploy 10MW for tenants at CA port
- **Solution:** Microgrid with 12 LGen paired with 18MWh storage
- **Impact:** Reduced time to power from 36 months to 9 months



# What we hear from customers

## Challenges They're Facing

- Unpredictable energy costs entirely at the mercy of utility
- Inability to manage costs or volatility over time

## Desired Business Outcomes

- Lower overall energy costs with less volatility in expenses
- Savings applied to other investments in business
- Revenue opportunities from previously cost-only assets

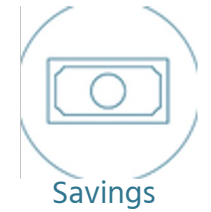
## Required Solution Capabilities

- On-site generation equipment with full dispatchability and load tracking, integration with microgrid controllers, high availability, high efficiency, and fuel flexibility
- Balance of plant components to support successful interoperation with other DERs
- Data logging and reporting

## Project Metrics

- Financial: project IRR, NPV, payback, and cost savings
- Fuel: efficiency, cost of fuel
- Predictability: trend in overall energy costs over time; % YoY change in costs

# Case Study The Kroger Co.



**Predictable and lower energy costs for the nation's largest traditional grocery company**



## Problem

- Reduce energy expenditures beyond what years of energy efficiency initiatives could provide
- Better manage risk associated with utility price volatility
- Minimize impact of increasing costs on tight profit margins

## Solution

- Deploy Linear Generators at grocery stores to offset power that would otherwise be sourced from the grid
- Finance LGen through energy service agreements
- Have Mainspring fully manage operations & maintenance

## Impact

Day 1  
savings

\$1M+  
per store  
over the  
lifecycle

Mainspring  
programs  
equivalent to  
opening  
profitable stores

“We have more control and ability to manage our costs and Mainspring has been nothing short of brilliant to work with. This checks all the boxes.”

*Denis George, Retired Senior Manager - Energy, The Kroger Co.*



Resilience

# What we hear from customers

## Challenges They're Facing

- Increasing number and frequency of grid outages; diminishing trust in reliability of utilities
- Resilience can be provided by diesel generators but is perceived negatively
- Diesels are an expensive insurance policy and sit idle the vast majority of the time
- Desire to enable backup power sources but challenging to make the business case for it

## Required Solution Capabilities

- On-site generation equipment that can grid-form and support islanded operations, fully dispatch and load track, and support full load steps and do so with high availability & high efficiency utilizing multiple fuel sources
- Balance of plant components to support fuel availability for uninterrupted operations during target operating hrs..
- Ability to participate in revenue-generating activities such as demand response

## Desired Business Outcomes

- Operations are immune to grid outages regardless of the length of the outage
- Flexibility exists to manage trade-offs between cost & carbon for different outage durations
- Approach is easily defended with low risk of negative attention / scrutiny

## Project Metrics

- Technical Operations: startup rate, time to load acceptance, availability, testing frequency
- Business Operations: absolute minutes of business interruption per year
- Losses: reduction in losses associated with power interruptions

	Agricultural Operations	Landfill Gas Processing	Wastewater Treatment
<b>Ultra-low NOx emissions</b> Easily permitted	◆	◆	◆
<b>High efficiency</b> Substantial energy production per MMBtu of biogas	◆	◆	◆
<b>Fuel flexibility</b> Able to run on a broad spectrum of biogas composition	◆	◆	◆
<b>Modular configuration</b> Supports operations of any size	Linear generators can operate on a broader scale of operation compared with other technologies due to their modular configuration and high efficiency. Products can be installed to provide onsite power for small dairies of <1,000 cows, up to large dairies of >5,000 cows.	◆	◆
<b>Additional application-specific value</b>	Less restrictive gas cleanup requirements and associated costs than fuel cells.  Onsite power for milking operations supports primary revenue stream.	New sources of revenue and improved carbon intensity scores by converting would-be-flared gas into electricity for export to the grid.	Power as-needed or 24/7/365 for critical wastewater infrastructure operations.

# Case Study Napa Sanitation District



**Providing renewable power and resilience during grid shutdowns or outages for wastewater collection and treatment**



## Problem

- Reduce cost and increase resilience for an essential public service to the local community
- Contribute to organization's Climate Change Mitigation Plan
- Increase utilization of anaerobic digester

## Solution

- Utilize Linear Generator to more efficiently convert biogas from anaerobic digester into clean power and to provide resilience during grid outages
- Increase biogas production by accepting more deliveries of waste fats, oils and grease as fuel for the linear generator and the facility's existing cogeneration system

## Impact

Higher facility reliability

Lower greenhouse gas emissions

Cost savings

"The linear generator is an important component of our Climate Change Mitigation Plan. The addition of this Mainspring unit to our plant will help us meet our clean energy goals, reduce greenhouse gas emissions, and create operational efficiencies."

*Tim Healy, General Manager, NapaSan*

# Clean, onsite energy generation using biogas for a leading dairy digester developer in California

## Business challenge

This developer captures biogas at dozens of dairy locations in California and upgrades and injects it into existing gas pipelines as a net-zero carbon fuel to be used to power vehicles or generate electricity.

They needed a solution to produce electricity from biogas directly, both to power their facilities in parallel with the grid and to operate independently from the grid to provide clean resilient power at these remote dairies.

## Project highlights

**Mainspring Linear Generators run on dairy biogas and form the backbone power generation source for dairy digester operations.**

- Four 230 kW Mainspring Linear Generators
- Renewable, clean power for the facility with near-zero NOx emissions
- Ideal combination of dispatchability, high efficiency, and low total cost of ownership
- COD expected 2024



## Customer outcomes

Mainspring Linear Generators run on biogas to provide 100% of onsite power needs while improving the economics for the customer and their dairy farm partners. Key benefits include:

### Cost Savings

Utilization of gas provides lower cost electricity compared to the grid and improves overall LCFS project economics.

### Resilience

Onsite prime power with backup ensures resilience for operations.

### Sustainability

Renewable power with near-zero NOx emissions.



# What we hear from customers

## Challenges They're Facing

- Utility dependency limiting ability to pursue projects and market opportunities
- Delayed project starts and business growth; revised group and corporate performance targets
- Uncertainty regarding what commitments can and can't be made to customers

## Desired Business Outcomes

- Team fully controls their own destiny and eliminates dependencies on utility
- Projects can move forward on desired timelines and customer commitments can be made with confidence
- Optionality exists around how to leverage utility interconnection once achieved

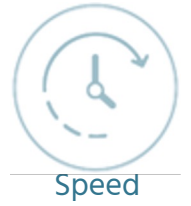
## Required Solution Capabilities

- On-site generation equipment that can grid-form and support islanded operations, fully dispatch and load track, and support full load steps and do so with high availability & high efficiency utilizing multiple fuel sources
- Balance of plant components to support fuel availability for uninterrupted operations during target operating hrs.
- Data logging and reporting

## Project Metrics

- Project: time from project start to commercial operations
- Technical Operations: site availability
- Financial: project IRR, NPV, payback, and TCO
- Fuel: efficiency, cost of fuel

# Case Study Prologis



**Clean, on-site EV charging infrastructure and prime power generation for a global leader in logistics real estate**



## Problem

- Rapidly deploy 10MW of EV charging infrastructure for tenants at CA port
- Local utility unable to meet power requirements in target timeframe

## Solution

- A fast, local, low-cost, clean microgrid to support the transition to net-zero emission transportation
- Twelve Mainspring Linear Generators paired with ~6MW / 18MWh of storage
- Ultimate flexibility after utility interconnection for continued self generation, cost savings from peak-hour shaving, and/or revenues from wholesale market participation

## Impact

Reduced time for new power from nearly 36 months to 9 months

Lower cost power than from the utility with clean resilience

“I spoke at #ACTExpo23 this week about bridging the gap of waiting for utility interconnections using our self-generation solutions that can also support grid resiliency later. Here are 5 things I hope people took away from the discussion ... 3. To meet heavy energy demands in small spaces, consider high-energy-density sources like bioenergy ... 5. Plan for future roles for self-generation after utility connection is established, such as emergency backup power and participating in resiliency programs where they exist.”

*JT Steenkamp, Director, Infrastructure Projects and Technology, Prologis*

# AEP avoids transmission constraints



- Perfectly sized, easily permitted projects
- Lower cost, longer duration than batteries
- Island-mode capable, clean-fuel ready
- Mobile and seasonal deployment options
- Accelerates electrification for EVs, buildings

“We are very interested in the scalability of Mainspring's flexible platform and its potential use in a variety of applications from customer-resiliency projects to grid-scale power plants.”

*Carlos Casablanca, Managing Director, Distribution Planning and Analysis for AEP*





Emissions

# What we hear from customers

## Challenges They're Facing

- Overwhelming number of potential paths exist towards pursuing Scope 1 and Scope 2 emissions targets
- Significant uncertainty and complexity with regulatory regimes and reporting requirements
- Sustainability budget and plans often get denied or reworked once formulated

## Desired Business Outcomes

- Clear path forward and plan in place to achieve targets
- Plan balances cost and timing while achieving targets, garnering executive buy-in and commitment
- Plans maintains operational and economic flexibility in terms of asset implementation
- Optionality exists to meet regulatory & reporting requirements whatever they turn out to be

## Required Solution Capabilities

- On-site generation equipment that can support net-zero and zero carbon fuels, firm renewables, and deliver high efficiency with low emissions
- Balance of plant components to support successful interoperation with other DERs (e.g., solar & batteries)
- Data logging and reporting for performance measurement & integration with GHG tracking systems
- Ability to engineer solution, as needed, for emissions to be treated as Scope 2 vs Scope 1

## Project Metrics

- Corporate: absolute CO<sub>2</sub>e (Scope 1/2); % CO<sub>2</sub>e reduction compared to baseline
- Project: carbon saved per dollar spent; economic value per dollar spent

# Lineage Logistics Case Study



**Clean on-site power generation  
for the world's largest and most innovative  
temperature controlled supply chain company**



## Problem

- Corporate commitments to achieve net-zero carbon emissions by 2040
- Exposure to frequent and unpredictable utility rate increases
- Grid outages threaten business operations and profitability

## Solution

- Two Linear Generators paired with 3.3MW rooftop solar
- Resiliency for key business operations during grid outages
- Companies exploring the use of 100% green fuels to power Mainspring's fuel-flexible products

## Impact

20  
years of  
savings

100%  
path to on-site  
clean power  
generation

Cleaner  
resilience

"Mainspring's technology will help support our move to net zero carbon energy, improve energy independence, and buffer our growing use of solar power, while offering the potential future use of zero carbon fuels like green hydrogen and others."

*Chris Thurston, Director of Energy & Sustainability, Lineage Logistics*

# Lineage Logistics – Sharon MA



Q & A

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