Presentations from Others

- On-Site Generation Presentations
 - Mainspring Energy Linear Generators
 - Hyliion Karno Linear Generators
 - Zeem Solutions Kaizen Fuel Cell Generator and Battery Energy Storage
- South Coast AQMD: Rule 1110.3





Onsite Power CARB TRIG

February 2025



Agenda

The challenges of the status quo

Solutions through onsite generation

Technology and use case

Key considerations

Mainspring



Power demand is growing at an unprecedented rate



Historical trend

For over two decades, the utility industry has been in a low growth period, well below 1% per year.

Faster than anticipated growth

Over the past two years, the 5-year load growth forecast has increased by almost a factor of five, from 23 GW to 128 GW.

Surge in electrical demand

Nationwide electric demand is forecast to increase by 15.8% by 2029.

Grid Strategies, Dec 2024:

https://gridstrategiesllc.com/wp-content/uploads/National-Load-Growth-Report-2024.pdf



Rapid demand growth is straining legacy infrastructure

THE WALL STREET JOURNAL. As Extreme Heat Disrupts Grids, Renewables, Distributed Energy Can Help

Published on Jul 19, 2024, 3:00 PM



A critical element of modernizing and decarbonizing the electric grid is addressing reliability risks posed by severe weather and rising demand.



The next generation of power plants will be virtual

by Justine Calma Oct 20, 2020, 10:00 AM EDT



Increasing numbers of homes outfitted with solar panels and batteries have the potential to help power entire regions with renewable energy.

BUSINESS INSIDER

What it will take to modernize the American grid and usher in the clean-energy revolution

Morgan McFall-Johnsen, Jenny McGrath, and Ellyn Lapointe May 13, 2024, 10:44 AM EDT



Cost

Emissions

Reliability

Speed



DER technology options for consideration

Technology	Restricted Power Output	Flexible Power Output
Combustion	Lean-burn engines Reciprocating internal combustion engines are widely used for Combined Heat and Power (CHP) in industrial applications	Microturbines Relatively small combustion turbines, well- suited for CHP applications
Non-combustion	Fuel cells Baseload power, capable of running on H2, RNG, biogas or NG (but no fuel-switching)	Linear generators Fast-ramping, full range of power output, low-emissions, capable of seamless fuel- switching between H2, RNG, biogas or NG



Electrifying mobility with Mainspring Linear Generators

- **Speed** deployed and installed <12 months
- Scalable 250 kW @480 3-phase AC per box, scalable to meet any power need with up to 25 MW/acre
- Seamless gaseous fuel switching runs on natural gas, biogas, propane, and hydrogen
- Resilient grid parallel and islanded operation
- Easy to permit and install Near-zero NOx emissions, UL listed
- Modular enables maintenance on individual modules for uninterrupted operation





Core technology enables flexibility and performance



- High Efficiency enabled by direct conversion of linear motion into electricity
- **Fuel Flexibility & Dispatchability** enabled by power electronics & software control of oscillators motion
 - Ultra-Low Emissions enabled by low-temperature, non-combustion reaction without a flame or burning
- Low Maintenance & High Reliability enabled by having only two moving parts riding on air



Case study: EV microgrid

Clean, onsite EV charging infrastructure for a global leader in logistics real estate



Problem

Utility could not meet 10 MW capacity need for EV charging infrastructure at shipping port



Pre-interconnection solution

Microgrid with 3 MW of linear generators and 6 MW / 18 MWh of battery storage



Post-interconnection optionality

Prime power Peak-hour shaving Clean resilience



Impact

Mainspring

Reduced time to power from 36+ months to 12 months



Flexible operating modes and fuel inputs enable evolving use cases

Phase 1: Get power onsite in less than 12 months



Baseload to meet capacity demand

Phase 2:

Optimize multi-asset usage to meet operational and financial goals

Peak shave Capacity increase Backup

Phase 3:

Meet sustainability goals by switching or blending zeroemission fuels



Switch to or blend zero carbon fuels







Dispatchable DER is a critical component of scaled fleet electrification

Speed and cost must be met without sacrificing emissions

Linear generators have been **deployed successfully** to meet all four requirements

With linear generators, DER purpose can evolve to match **evolving business needs**







Thank you!



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Rethink



HYLIION | OVERVIEW







OUR MISSION

Hyliion is creating innovative solutions that enable clean, flexible and affordable electricity production

How KARNO works

An innovative, heatpowered linear generator that leverages Stirling technology and flameless oxidation to produce clean electricity



How KARNO works

An innovative, heatpowered linear generator that leverages Stirling technology and flameless oxidation to produce clean electricity



CENERATOR



LINEAR GENERATOR that uses HEAT to produce electricity

Image for illustrative purposes only. Actual production design is subject to change.

HYLIION® 2024 | Proprietary & Confidential – Do not forward or distribute

HYLIION[®] KARNO GENERATOR

BENEFITS

FUEL AGNOSTIC 🥤 20+ fuels

ULTRA-LOW EMISSIONS () <4 ppm NOx & CO

SUPERIOR EFFICIENCY 7 50%

LOW MAINTENANCE COST X 1 moving part

LOW NOISE 🚿 <67 dB

DISPATCHABLE POWER WITH BLACK START CAPABILITY

HYLIION® 2024 | Proprietary & Confidential – Do not forward or distribute



Fuel agnostic and reduced emissions

Conventional fuel Natural gas Alternative fuel **HYDROGEN** Gaseous Hydrogen Renewable natural gas Diesel Liquid Hydrogen Gasoline Ammonia Compressed natural gas Kerosene **Dimethyl** Ether Liquified natural gas Jet Fuel (JP8)

Emissions Standards

The KARNO[™] generator is expected to comply with all current and foreseeable emissions standards, specifically from CARB and EPA, even when utilizing conventional fuels.¹

Hydrogen capable

The KARNO^{TM} generator is expected to operate on Hydrogen at efficiency levels that even surpass most of today's leading fuel cell solutions.¹

+ others

¹Preliminary modeling results

VERSATILITY: APPLICATIONS





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Breakthroughs in Additive Manufacturing (3D Metal Printing) drive the KARNO generator's unparalleled performance

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POWER LEVELS





MODULAR & SCALABLE





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Thank you

TRUCK REGULATION IMPLEMENTATION TOM GAGE **FEBRUARY 2025**

Full-Service Charging for Commercial Fleets

Zeem's Impact in 2024 – Over 4.5M kWh of electricity dispensed, fueling over 125,000 charging sessions

- Shared-use or dedicated sites for customers under contract
- Two sites in operation, three more to open 2025
- Barriers to EV adoption by fleets
 - High-cost of equivalent facilities vs diesel refueling
 - Insufficient power at sites
 - Cost and time for grid upgrades
 - Uncertainty regulations, economics, technology
- Zeem solutions under development
 - High utilization of assets
 - Mobile and stationary batteries
 - On-site generation



Power Profile – LAX Depot

Jan 16, 2025 Peak power – 2430 kW Average power – 925 kW (22180 kWh/day)





Off-grid On-site Power

Objectives:

- Power for charging
- Fast set-up
- Temporary (transportable) •
- Acceptable opex
 - Small on-site footprint
 - Regulatory compliance

 Low capex for fleet operator

Mobile battery – Demonstration, December 2024

- 1.2 MWh, 500 kW output, two units
- Three 175 kW DCFCs
- Charge at Zeem's Aviation Blvd power hub
- Discharge at Wilmington, CA drayage cross-dock

KCE Methanol/Fuel Cell Generator – Proposal for 2025

- 130 kW continuous output
- On-site methanol fuel storage
- One 180 kW DCFC
- Can charge buffer battery when not charging vehicles











Mobile Batteries

- Two mobile batteries, 1000VDC, 1.2 MWh each
- One battery charges while the other discharges
- Self-contained power conversion, up to 500 kW output at 480 VAC
- Self-contained thermal management system
- Up to 3 cycles/day, for each battery, can deliver ~ 7000 kWh/day





One-Day Set Up – Power Hub

Aviation Blvd

- 300 kW, 480VAC grid connection
- 600A transfer switch
- Skid-mounted transformer





One-Day Set Up – EV Depot

Wilmington, CA Cross-dock

- Skid-mounted transformer
- Skid-mounted remote-control switchgear
- Three trailer -mounted 175 kW DCFCs









ON-SITE GENERATION

Kaizen Clean Energy Methanol/Fuel Cell Generator



On-site H2 production + fuel cell + batteries = produce power when you want, no grid, etc.

Operational Prototypes

Kaizen Clean Energy System

- Three 20' containers:
 - Methanol/fuel cell generator
 - Thermal management
 - Methanol fuel storage
- One or more DCFCs
- Can load-follow or charge stationary battery when not charging vehicles
- ~ 3500 kWh/day
- 150 kW continuous
- Torture-tested as charging source for Extreme E electric SUV racing series





Methanol Fuel Advantages

- Hydrogen is generated on-site to minimize transport issues
- Methanol is lowest cost H2 carrier
- Methanol is safe
 - Flammability and combustibility like diesel
 - Water soluble
 - Liquid, not gas
- Methanol is readily available -
 - Globally produce
 - Widely distributed
 - Los Angeles is Green Methanol corridor
- Methanol/fuel cell generates zero NOx, SOx, particulates





- Off-grid power is necessary for acceleration of fleet electrification.
- Solutions that are scalable, convenient, versatile, transportable, are easier to implement and finance.
- Charging economics are difficult. Diesel refueling is >100 times faster than battery charging. Diesel infrastructure is not a good model for EV charging.
- Utility and PUC participation and adaptation are necessary over the long term. Off-grid power may help spur necessary changes.





Rule 1110.3 – Emissions from Linear Generators

CARB – Truck Regulation Implementation Group February 10, 2025

Background

In 2019, during the amendment of Rule 1110.2 – Emissions from Gaseous- and Liquid-Fueled Engines (Rule 1110.2), staff was informed of linear generator technology and established emission standards for linear generators in Rule 1110.2

Due to its unique operating characteristics and to allow for specific considerations and capabilities of this new technology, South Coast AQMD developed a rule specifically for linear generators

Rule 1110.3 – Emissions from Linear Generators, was adopted in November 2023, and established emission limits for linear generators, as well as provisions for source testing, monitoring, reporting, and recordkeeping

Unique Characteristics of Linear Generators

Electricity Production via Electromagnetic Induction

 Magnets are driven through copper coils in a linear motion to produce electricity

Low Emissions Profile

- Lower reaction temperatures result in lower NOx and CO emissions
- Low NOx emissions are achieved without add-on pollution control equipment
- No catalyst heating required, which results in low NOx levels at startup

Rule 1110.3 Applicability and Emission Limits

Rule 1110.3 applies to natural gas fired Units

A Unit is defined as any single linear generator core

Emission limits are based on achievability and backed by source test data

Table 1: Concentration Limits for Linear GeneratorsUnits with a Permit to Operate Issued on or after November 3, 2023				
Natural Gas	2.5	12	10	

¹ Parts per million by volume, corrected to 15% oxygen on a dry basis and averaged over 15 minutes.

² Parts per million by volume, measured as carbon, corrected to 15% oxygen on a dry basis, and averaged over the sampling time required by the test method.

NOx Emissions Comparison

NOx emissions mirror limits in South Coast AQMD Rule 1135 – Emissions of Oxides of Nitrogen from Electricity Generating Facilities*

*Rule 1135 NOx limit for Simple Cycle Gas Turbines = 2.5 ppmv

NOx emissions also meet standards in CARB's Distributed Generation Certification Program for electrical generation technologies**

**CARB DG Standard for NOx = 0.07 lb/MW-hr

Rule 1110.3 Source Testing Requirements and Test Methods

- Conduct source testing every 5
 years
- Pooled testing option for 6 or more units located at a single facility
 - Pooled testing conducted on one-third of units every 3 years
- Source tests are required to be conducted according to the test methods in Table 2

Table 2: Testing Methods			
Pollutant Method			
NOx	South Coast AQMD Method 100.1		
СО	South Coast AQMD Method 100.1		
NOC	South Coast AQMD Method 25.1*		
VUC	or Method 25.3*		

*Excluding ethane and methane

Other Rule 1110.3 Requirements

Maintenance Requirements

• Inspect and maintain sensors, meters, and oxidation catalyst (if applicable) per manufacturer's requirements

Monitoring

• Portable analyzer testing every 2 years

Recordkeeping and Reporting

Current Applications









Potential Applications

Back-up Power

- Hospitals and other healthcare facilities
- Data Centers
- Other emergency applications



Future Plans and Considerations

Explore Fuel-Agnostic Capabilities

- Hydrogen
- Methane
- Renewable Fuels

Evaluate Durability and Robustness

- Emissions
 Performance
- Life Expectancy

Characterize Other Emissions

- Particulate Matter
- Toxic Air Contaminants

Update Rule

- Fuel-Specific Emission Limits
- Alignment with other South Coast AQMD Rules
- Certification Program

Contacts

(Adopted November 3, 2023)

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RULE 1110.3 EMISSIONS FROM LINEAR GENERATORS

- Purpose The purpose of this rule is to reduce emissions of Oxides of Nitrogen $(NO_{x}),$ Volatile
- Organic Compounds (VOCs), and carbon monoxide (CO) from linear generators.
 (b) Applicability
 All linear generators fueled solely by natural gas are subject to this rule.
- (c) Definitions

(a)

For the purpose of this rule, the following definitions shall apply:

- (1) EMERGENCY STANDBY UNIT means any Linear Generator which operates as a temporary replacement for primary power during periods of fuel or energy shortage or while the primary power supply is under repair.
- (2) FACILITY means any source or group of sources or other air contaminant emitting activities which are located on one or more contiguous properties within South Coast AQMD, in actual physical contact or separated solely by a public roadway or other public right-of-way, and are owned or operated by the same person (or by persons under common control), or an outer continental shelf (OCS) source as determined in Section 55.2 of Title 40, Part 55 of the Code of Federal Regulations (40 CFR Part 55). Such above-described groups, if noncontiguous, but connected only by land carrying a pipeline, shall not be considered one facility. Sources or installations involved in crude oil and gas production in Southern California Coastal or OCS Waters shall be included in the same facility which is under the same ownership or use entitlement as the crude oil and gas production facility on-shore.
- (3) IDENTICAL UNITS means any Units with the same manufacturer, model, and output rating.
- (4) LINEAR GENERATOR means any power generation technology that uses a thermochemical reaction to create linear motion that is directly converted into electricity.

1110.3 - 1

<u>Rule 1110.3</u> <u>Link</u>