

How fuel cells can transform wastewater treatment plants into renewable energy producers



FuelCell Energy: a global leader in fuel cell technology

OPERATING SINCE 1969

FuelCell Energy is a global leader in decarbonizing power and producing hydrogen through our proprietary fuel cell technology

FuelCell Energy is working to:

- **Produce** low- to zero-carbon power
- **Capture** carbon and greenhouse gasses while simultaneously generating power
- **Supply** green or blue hydrogen energy
- **Store** energy from intermittent renewables by converting excess power to hydrogen – then converting back into power when it’s needed or delivering to other applications

- **Danbury, CT, USA**
Corporate headquarters
- **Torrington, CT, USA**
Carbonate manufacturing
- **Taufkirchen, Germany**
Assembly & service
- **Calgary, Canada**
Solid oxide R&D/manuf.

COMPANY HIGHLIGHTS

HQ Danbury, Connecticut
 >500 Employees
 95 Platforms in Commercial Operation
 3 Continents
FCEL Listing: NASDAQ
>225 MW Capacity in Field
>15 Million MWhs generated with SureSource patented technology

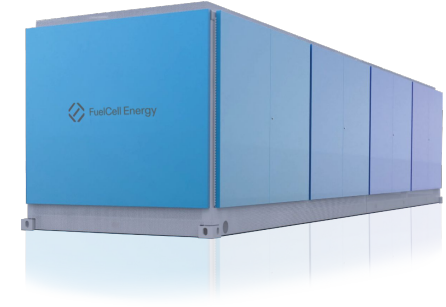
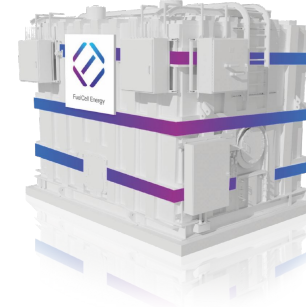


GLOBAL CUSTOMERS



Two leading technologies providing energy solutions

TWO ADVANCED HIGH-TEMPERATURE ELECTROCHEMICAL PLATFORMS ADDRESSING MULTIPLE APPLICATIONS



| Application | | Carbonate | Solid oxide |
|----------------------------|---|-----------|-------------|
| Power Gen & CHP | using natural gas, biogas, or H ₂ blends | ✓ | ✓ |
| | using pure hydrogen fuel | | ✓ |
| Carbon Capture | from platform | ✓ | ✓ |
| | from external source while making power | ✓ | |
| Hydrogen | hydrogen, power, water from natural gas or biogas | ✓ | ✓ |
| | high-efficiency electrolysis hydrogen production | | ✓ |
| | long duration hydrogen-based energy storage | | ✓ |

Carbonate power generation platforms



400-cell fuel cell stack package



Four-stack module
1.4MW



1.4 MW net power
47% electrical efficiency
up to 90% total efficiency



2.8 MW net power
47% electrical efficiency
up to 90% total efficiency



Tri-generation
2.35 MW net power
1,270 kg/day hydrogen
1,400 gal/day water



Carbon Recovery
1.3-1.8 MW power
20+ Mt/day CO₂



14 MW (Derby, CT)



15 MW (Bridgeport, CT)



59 MW (Korea)

Large-scale fuel cell parks

Carbonate power generation applications

Grid Support with CHP

- 20 MW site built in 2018
- Power sold to grid
- Heat sold to district heating
- 6 month construction time
- Easily scalable



Grid Support / Urban Redevelopment

- 15 MW on 1.5 acres
- Power sold to grid
- Enhanced resiliency
- Brownfield revitalization
- 12 mo. Installation



Resiliency for Pharma

- 5.6 MW w/steam for company campus
- Reliable power solving local grid instability
- Immediate cost savings
- Complements ESG goals



Fuel Cell / Solar Integration

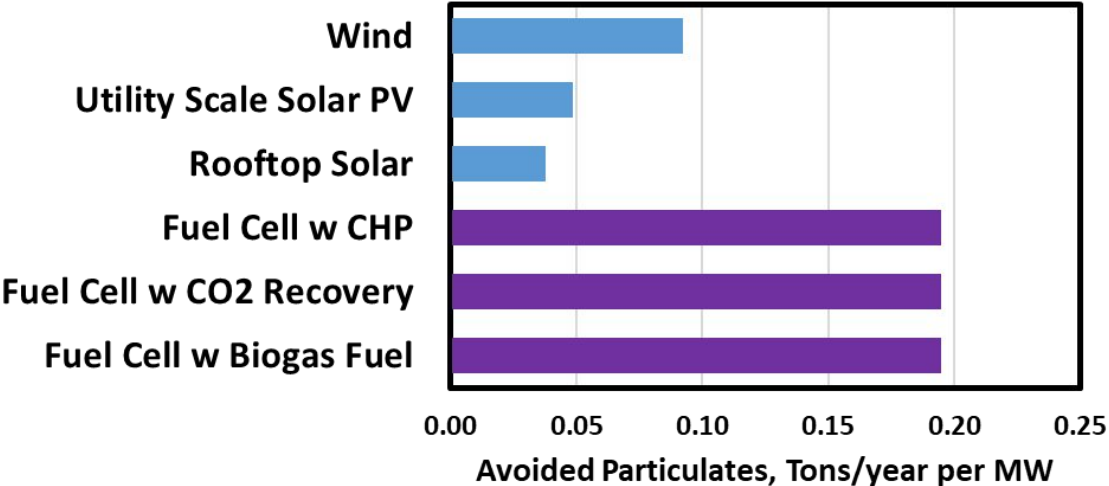
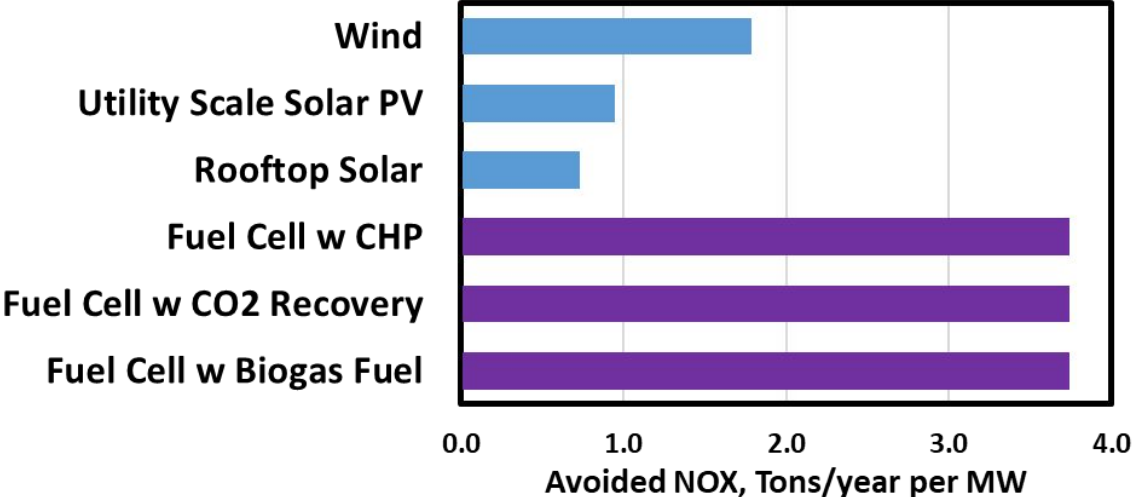
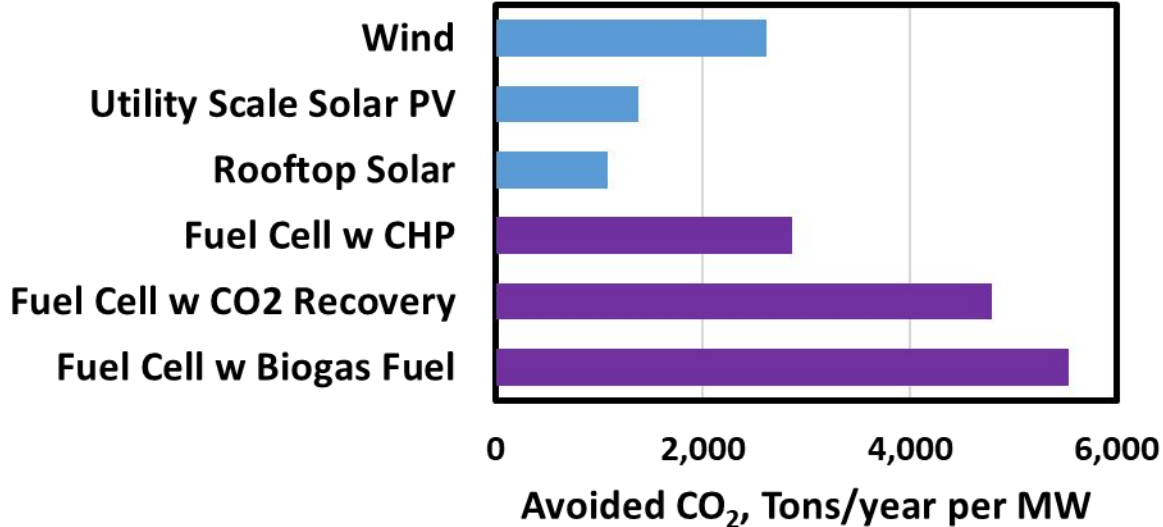
- 2.8 MW fuel cell on ¼ acre
- 2.2 MW solar on ~9 acres
- Utility-owned, rate-based
- Enhanced resiliency



MORE THAN 15 MILLION MWH GENERATED BY CARBONATE POWER PLATFORMS

Effective emissions reductions

| | Capacity Factor, % | Emissions, lb/MWh | | | Avoided Emissions, Tons/y per MW | | |
|--|--------------------|-------------------|---------|------|----------------------------------|------|-------|
| | | NOX | PM | CO2 | NOX | PM10 | CO2 |
| Average US Grid | | 0.96 | 0.0495 | 1405 | | | |
| Carbonate Fuel Cell with biogas fuel | 90% | 0.01 | 0.00002 | 0 | 3.7 | 0.20 | 5,540 |
| Carbonate Fuel Cell w CO ₂ Recovery | 90% | 0.01 | 0.00002 | 189 | 3.7 | 0.20 | 4,795 |
| Carbonate Fuel Cell with CHP | 90% | 0.01 | 0.00002 | 680 | 3.7 | 0.20 | 2,859 |
| Rooftop Solar | 18% | | | | 0.7 | 0.04 | 1,077 |
| Utility Scale Solar PV | 23% | | | | 0.9 | 0.05 | 1,385 |
| Wind | 43% | | | | 1.8 | 0.09 | 2,616 |



Sources:
 Grid emissions rates for NOX and CO2 From EPA eGrid 2022, US Average non-baseload rates
 PM emissions from EPA eGrid PM 2.5 US average for 2020 from eGrid 2022
 Capacity factor for solar are averages of ranges from Lazard LCOE Analysis version 17, June 2024

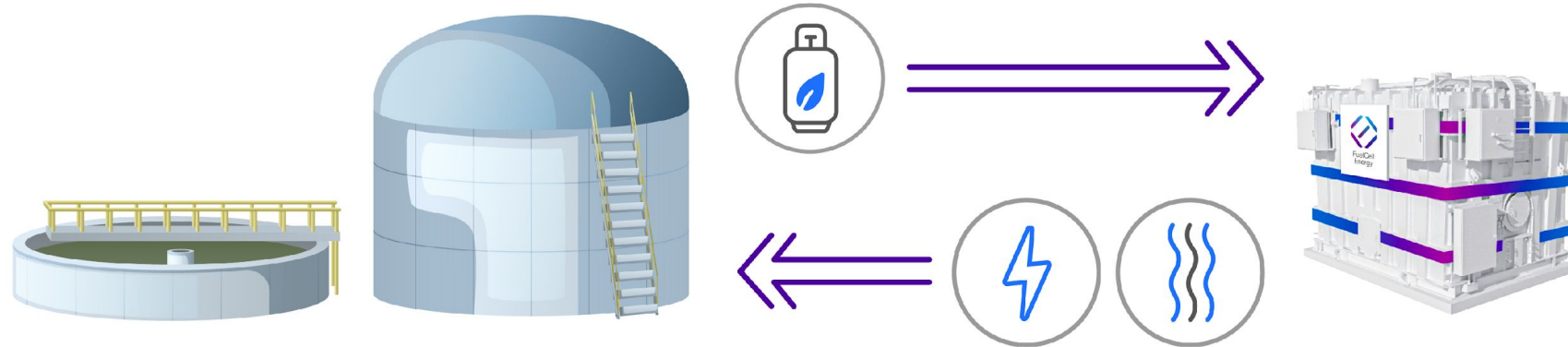
Fuel cell applications at treatment plants



Deploying fuel cells at water treatment facilities provides significant benefit to water treatment plant operations:

- On site production of clean power and heat
- In many cases, lower cost electricity than available from utility
- Utilization of on-site biogas
 - Avoided flaring
 - Avoided emissions from flaring or combustion-based power generation
- Optional co-production of valuable bi-products
 - Hydrogen
 - Carbon Dioxide
 - Water

Biogas in. Renewable energy out



- Runs directly off digester gas at high efficiency to produce renewable electricity and useful heat.
- Our proprietary treatment system removes siloxanes and sulfur compounds to maximize useable biogas.
- The gas does not need to be cleaned up to pipeline standards, reducing cost and improving efficiency.

Our fuel cell systems are designed to thrive in applications that use anaerobic digester gas

Digester gas vs natural gas



Natural Gas

- 90 – 100 % Methane, balance typically higher hydrocarbons
- 900 – 1000 Btu/ft³
- Dry
- Very Low Oxygen, except peak shave gas
- Odorized for safety, typically 3ppm sulfur, max 20 ppm

Digester Gas

- 50% - 80% Methane (60% typical), balance typically CO₂
- 500 – 800 Btu/ft³, 550 Btu/ft³ typical
- High humidity
- Fraction to a few percent Oxygen
- Sulfur present naturally, at tens to hundreds of ppm, also often contains Siloxanes

Decades of experience with digester gas as fuel

- FuelCell Energy's first commercial powerplant sale was for a biogas application, at a Kirin Beer brewery in Japan
- This was followed by multiple applications at breweries, food waste processors, and municipal water treatment plants
- An advanced feature set has been developed to optimize the application of carbonate fuel cells with biogas:
 - Added fuel flow capability to handle lower Btu content
 - Developed dual fuel and fuel blending approaches to deal with digester gas flow interruptions
 - Developed improved fuel treatment and clean up technology and improved technology for monitoring impurities



**250kW Carbonate CHP Powerplant
deployed at Kirin Brewery, Japan, in 2003**

FuelCell Energy biogas application advantages

High level of CO₂ tolerance: Our carbonate fuel cells can operate at full power with fuel CO₂ content up to 40% and with only minor degradation up to 50%.

Dual-fuel capability: Our carbonate fuel cells can operate on blends of on-site biogas and natural gas, maintaining output during biogas availability fluctuations

Industry-leading gas cleanup: FCE has multiple biogas-fueled installations with proven experience in removing fuel contaminants (sulfur, siloxanes, water, oxygen)



Advanced fuel gas monitoring: FCE's proprietary approach to sulfur detection provides industry-leading contaminant sensitivity

Combined heat and power (CHP) platform: Industrial scale renewable electricity and useful heat for plant operations and digester heating needs. High overall Digester Gas CHP efficiency (electricity + heat output) maintained above 70% LHV efficiency under normal system aging

Expertise developed over two decades of biogas projects



City of Riverside (1.4 MW)

The SureSource 1500™ fuel cell plant cleans and consumes renewable biogas from the wastewater treatment process to generate carbon-neutral power and heat for the facility.

- 24/7 power profile
- Limited capital costs
- Heat supports anaerobic digesters



San Bernardino (1.4 MW)

The SureSource 1500™ fuel cell plant supports the City of San Bernardino Municipal Water Department using anaerobic digester gas (ADG) and supplemental natural gas as needed.

- Carbon-neutral power
- Heat support anaerobic digesters
- Biogas cleaned with FCE conditioning system



Tulare (2.8 MW)

The SureSource 3000™ fuel cell system is fueled by the City's biogas which is treated using the SureSource Treatment™ fuel cleaning system.

- Carbon-neutral power
- Now uses biogas instead of flaring it
- Benefits from the state's BioMAT program

We have more than 500,000 operating hours of experience from decades of biogas-fueled projects

California Air Resources Board (CARB) certified for operation on biogas at low emissions

California onsite biogas operating experience



- Our carbonate fuel cells are certified under CARB standards, expediting the permitting process in certain clean air districts.
- Outside the state of California, the CARB 2007 certification can independently validate the clean air profile of our plants.
- When operating on biogas, fuel cells are considered low-carbon or even carbon-negative (depending on the type of biogas).
- The fuel cell's chemical reaction is virtually free of NO_x, SO_x, and particulate matter emissions.
- The fuel cell can also improve local air quality by allowing a site to turn off their boilers or eliminating the need to flare biogas.
- Fuel cell projects also qualify for many incentive programs.

Our platform's clean emissions profile allows for a faster and simpler path to air permitting

Carbonate fuel cell power generation platforms

FuelCell Energy's carbonate platform has demonstrated our ability to provide low-carbon, dispatchable power for a variety of applications worldwide.

After 20+ years of operations, the carbonate fuel cell platform continues to evolve to meet tomorrow's energy needs for:

- Utility-scale power
- Commercial and industrial CHP applications
- On-site biogas
- Combustion-free, quiet, compact generation
- CARB emission-compliant generation
- Microgrid applications
- Datacenter power
- Carbon solutions



| | 1500 | 3000 |
|---|-----------------------------------|-----------------------------------|
| Net Power Output | 1.4 MW | 2.8 MW |
| Heat Energy for Recovery, 250°F / 120°F | 2,216,000 BTU/h / 3,730,000 BTU/h | 4,433,000 BTU/h / 7,460,000 BTU/h |
| Efficiency LHV | 47% +/- 2% | |
| NOx Emissions | 0.01 lb/MWh | |
| SOx Emissions | 0.05 g/MWh | |
| CO2 Emissions | 980 lb/MWh | |
| CO2 Emissions with Heat Recovery | 520-680 lb/MWh | |

Solid Oxide fuel cell power generation platform

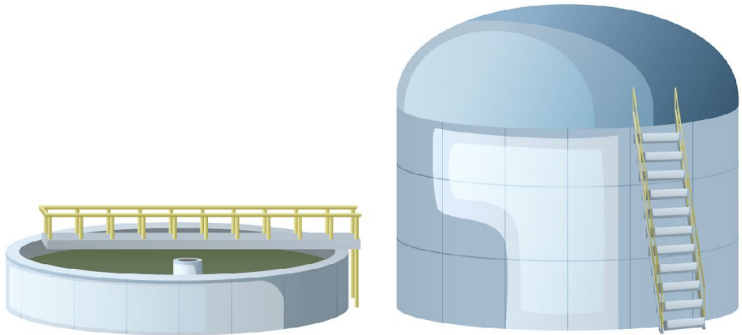


Benefits

- Scalable from 250 kW to multi-MW installations
- Low levelized cost of electricity (LCOE)
- Low carbon footprint for improved sustainability
- Fuel flexibility and future-proofing through H₂ blending
- Microgrid-capable
- Rapid deployment with reduced site design, installation and commissioning
- Repeatable, factory-certified performance

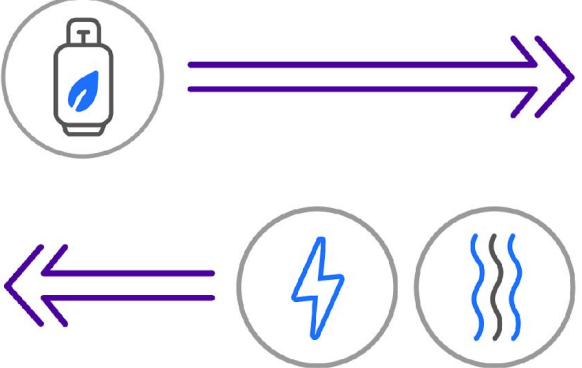
| | Natural Gas Fuel | Biogas Fuel (60% Methane) |
|--|-------------------------------------|--|
| Net Power Output | 250 kW | |
| Part Power Capability | 10% – 100% | |
| Dynamic Response | 10% per minute | |
| Heat Output (Max) | 382,000 BTU/h | 471,000 BTU/h |
| Efficiency, Electrical / Overall (LHV) | 62% / 90% | 58% / 90% |
| Dual-Fuel Option | Natural Gas & Hydrogen | Natural Gas & Biogas |
| Fuel Blending Range | 0% - 100% Hydrogen | 0% - 100% Biogas |
| NOx and CO Emissions | 0.01 lb/MWh | |
| CO ₂ , Electric Only / With Heat Recovery | 715 lb/MWh / 494 lb/MWh | Neutral to negative dependent on biogas source |
| Noise | 72 dBA @ 10 ft, option for < 65 dBA | |

Example of digester fuel cell application



45 MGD digester

- Digester gas:
- 18,750 scfh
 - 10.2 MMBtu/h, 3MW LHV



1.4MW carbonate fuel cell

- Fuel cell output:
- 1.4 MW power at 47% LHV efficiency
 - 1.4 MMBtu/h heat to support digester
 - ~2MMBtu/h additional heat available for other applications

Digester production and heat requirement based on estimates in:
Opportunities for Combined Heat and Power at Wastewater Treatment Facilities: Market Analysis and Lessons from the Field;
U.S. Environmental Protection Agency, Combined Heat and Power Partnership,
October 2011

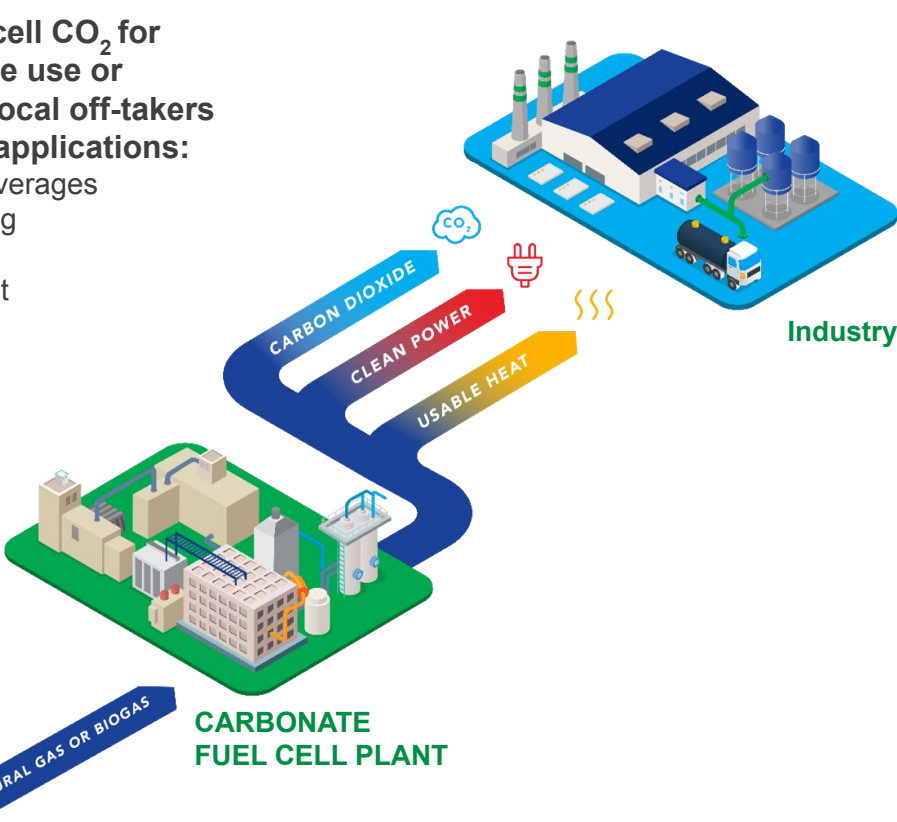
Carbonate CO₂ recovery and capture applications

Carbon Recovery

Purification and capture of CO₂ from fuel cell power generation

Capturing fuel cell CO₂ for supply to on site use or distribution to local off-takers for a variety of applications:

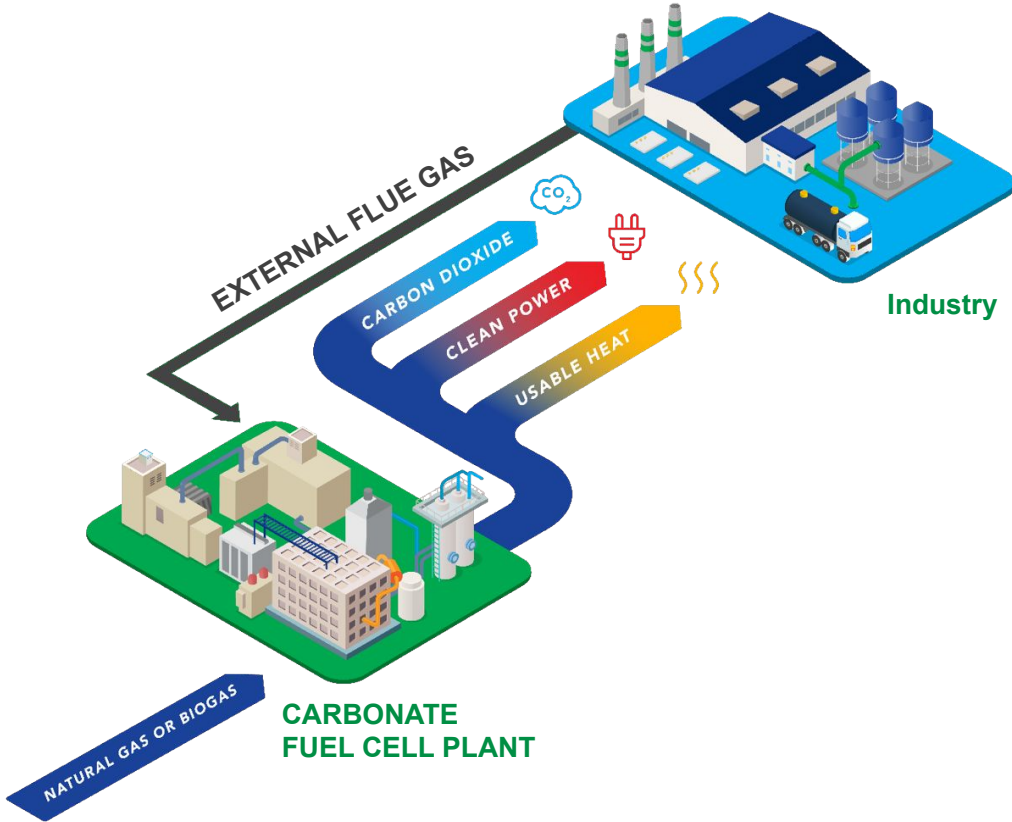
- Carbonated beverages
- Food processing
- Dry ice
- Water treatment
- Agricultural
- Cement
- Plastics
- E-Fuels



Commercially available today

Carbon Capture

Purification and capture of CO₂ from external flue gas



Commercially available today for select applications and under development with ExxonMobil for large scale applications

Powering Toyota's Port of Long Beach operations



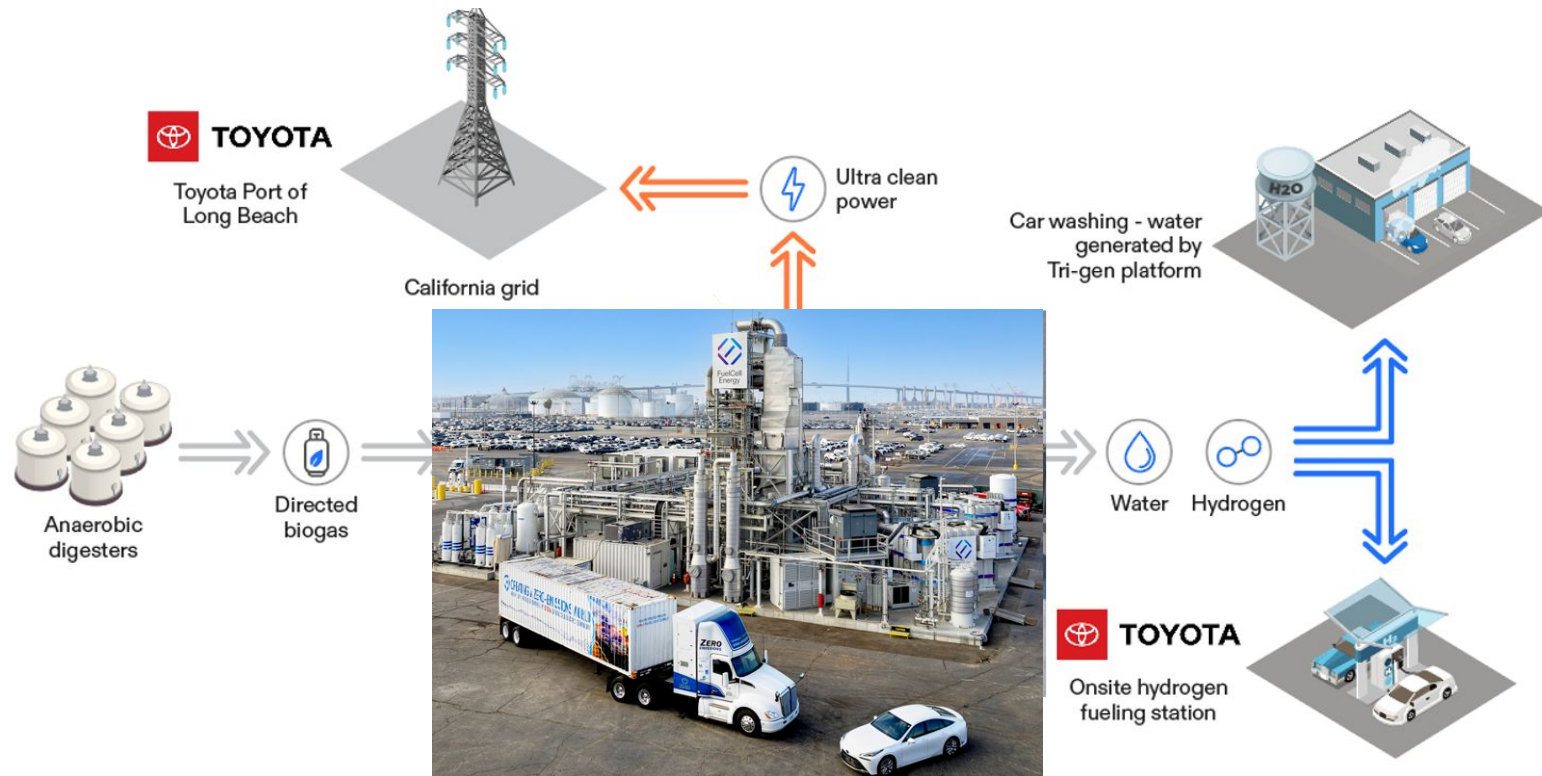
“ By utilizing only renewable hydrogen and electricity production, this operation blazes a trail for our company. Working with FuelCell Energy, together we now have a world-class facility that will help Toyota achieve its carbon reduction efforts, and the great news is this real-world example can be duplicated in many parts of the globe. ”

Chris Reynolds,
Chief Administrative Officer, Toyota



Tri-gen: How it works

- Hydrogen production from methane reforming using fuel cell heat and water during power co-production
- Compared to conventional steam methane reforming (SMR):
 - No fuel combustion for process heat
 - No water consumption
- Avoided combustion emissions, lower CO₂
- The system produces up to:
 - 2.3MW of electricity
 - 1200 kg of hydrogen per day
 - 1400 gallons of water per day



Tri-gen on-site biogas application



- Operation with on-site biogas may be best value proposition
 - Low-cost renewable fuel
 - Minimal fuel upgrading required since carbonate can operate on dilute biogas
 - Co-production of power, heat, and water supports water treatment facility operation
 - FCE has extensive experience in biogas processing and on-site biogas power projects at wastewater treatment plants and breweries
 - The first demonstration of Tri-gen was at the wastewater treatment plant of Orange County Sanitation District in Fountain Valley, CA using on-site biogas with on-site hydrogen filling station

Questions?

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<https://www.fuelcellenergy.com/solutions/waste/wastewater-treatment-plants>