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The #H2IQ Hour

Today's Topic:
Megawatt-Scale Tri-Gen System

This presentation is part of the monthly H2IQ hour to highlight hydrogen and fuel cell research, development, and demonstration (RD&D) activities including projects funded by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

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HOUSEKEEPING

This webinar is being recorded.

This webinar is being recorded and will be available on the H2IQ webinar archives.

Technical Issues:

- If you experience technical issues, please check your audio settings under the “Audio” tab.
- If you continue experiencing issues, direct message the host, Kyle Hlavacek

Questions?

- There will be a Q&A session at the end of the presentation
- To submit a question, please type it into the Q&A box; **do not** add questions to the Chat

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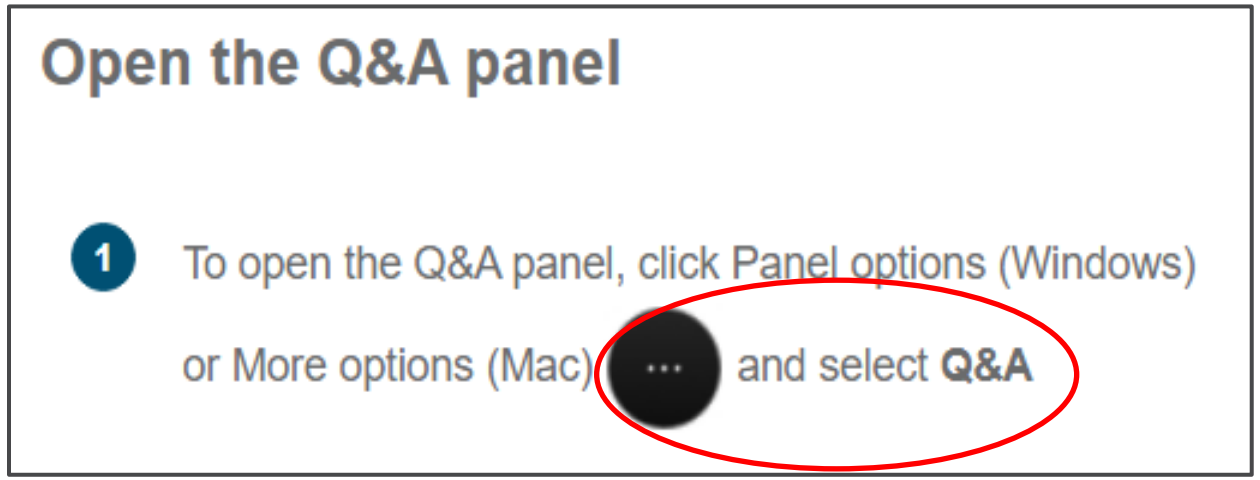
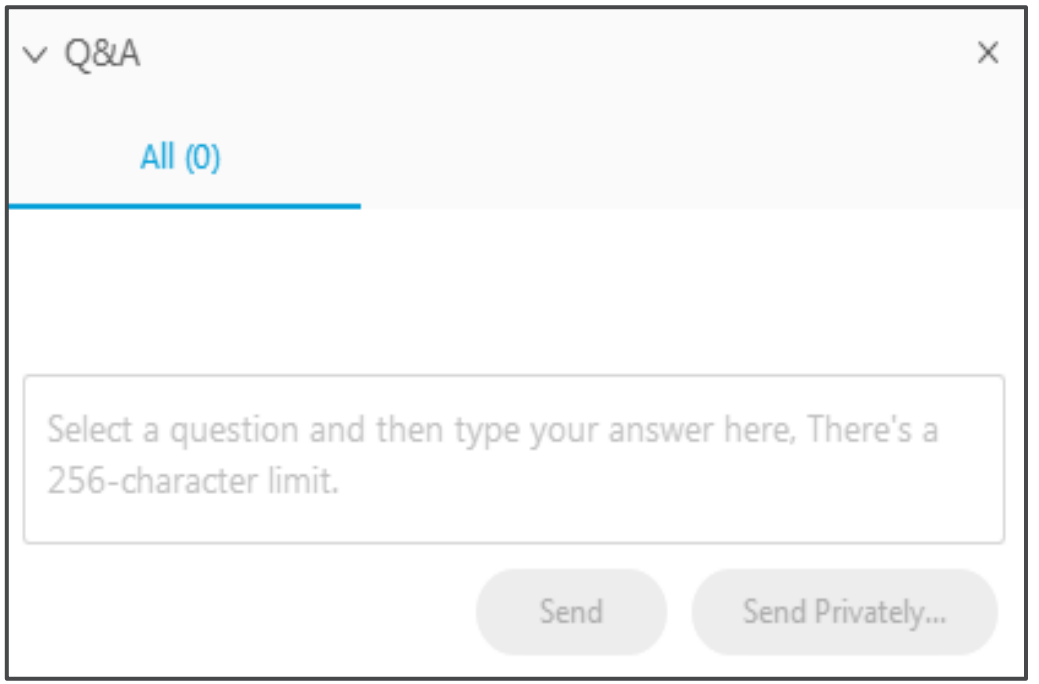
The #H2IQ Hour Q&A

Please type your questions in the Q&A Box





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HYDROGEN AND FUEL CELL TECHNOLOGIES OFFICE

May H2IQ Hour Webinar: Megawatt-Scale Tri-gen System Produces Clean Hydrogen, Electricity, and Water at the Port of Long Beach

TOYOTA

Mark Yamauchi, LEED AP
Environmental Sustainability Manager

FuelCell Energy

Tony Leo
Chief Technology Officer

Global environmental commitments

Toyota Goals:

- Environmental Challenge 2050
  - **Zero carbon** operations and lifecycle of products
  - **Water** optimization and minimization
  - Circular economy
  - Biodiversity
- **Carbon Neutrality** for facilities by 2035
- **Science Based Target** Plan

CARBON

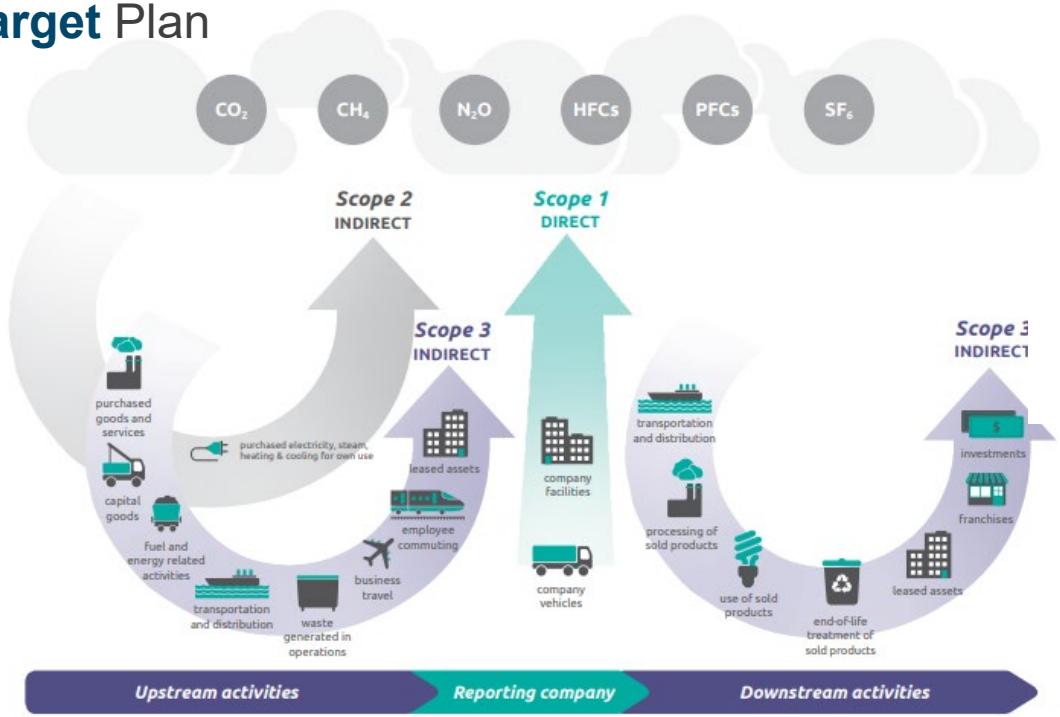
WATER

TOYOTA ENVIRONMENTAL CHALLENGE 2050

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

THE NET ZERO STANDARD
APPROVED NET-ZERO TARGETS

CSRD



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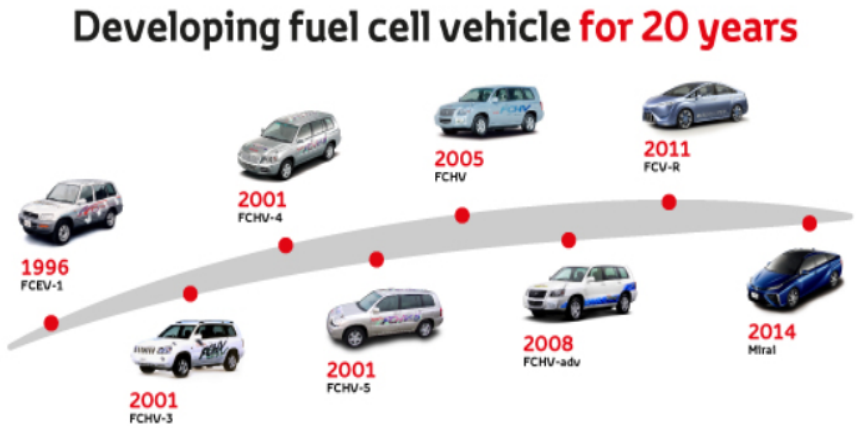
Hydrogen fuel cell vehicle chronology

Two decades of technology research

We believe the hydrogen fuel cell system is a technological breakthrough with the potential to deliver sustainable, zero-emissions mobility as part of a low carbon society.

We began our research and testing programme 20 years ago. About the same time we started work on Prius, and we are confident that we have succeeded in capturing the benefits hydrogen can offer in a vehicle that meets the needs of today's customers. At the same time it addresses future concerns about air quality and sustainability.



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BEYOND ZERO

Electrified Vehicle Portfolio

HEV

RAV4 Hybrid

PHEV

Prius Prime

FCEV

Mirai

BEV

bZ4x

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Toyota North America Operations

- Over **120** facility sites
  - 13 **factories**
  - 3 **port processing** facilities
  - **R&D and Design** facilities
  - **Parts Distribution** facilities
  - Regional **Sales & Training** facilities

- Corporate footprint:
  - Over **12,140 Hectares** (30,000 Acres)
  - **3,250,000 square meter** (35M square feet)

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Toyota Logistics Services Long Beach

- **Toyota Logistics Services** (TLS) Long Beach
  - Port processing operations since mid **1960**s
  - **46 Hectare** Site (114 Acre)
  - **13,750 square meter** (148,000 square foot) consolidated operations building.
  - Process ~ **180,000 vehicles/year**
- **Goals**
  - New TLS operations building and site renovation design starts in **2016:**
    - Increased **operational efficiency**
    - Seismic **code compliance**
    - Plan for **zero carbon** operations
    - **Mirai** gen 2 fueling
    - Support **HD FC Truck** Program
    - Sustainability to be validated by **LEED** (Leadership in Energy and Environmental Design) certification (pending)
- Building completed in **2022**

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Stationary Hydrogen Chronology

- **2001** Toyota Torrance HQ “hydrogen support” modifications and **Hydrogen Fuel Cell Vehicle Prototype** deployment
  - Service and maintenance facility for Hydrogen Fuel Cell Vehicle
  - Fueling station with onsite hydrogen generator
- **2007** Gills Onions demonstration project
- **2011** Orange County Sanitation District tri-gen demonstration project
- **2012 World’s first** 1.1 MW **pipeline fed PEM Fuel Cell** installed at Toyota Torrance Campus
- **2012 Light duty** pipeline fed hydrogen **fueling station** install on Toyota property
- **2015** Toyota Motor North America HQ in Plano, TX designed with infrastructure for future Campus Hybrid Electric System to be “hydrogen ready”
- **2016** Plans for new TLS Long Beach (LB) Operations buildings integrate sustainability design.
- **2016** “Project Portal”, Class 7 HD Fuel Cell Electric Truck renewable hydrogen fuel and dispensing need
- **2017** Toyota and FuelCell Energy execute long term Hydrogen Power Purchase Agreement
- **2019** Construction begins on TLS LB Operations buildings and Heavy-Duty Hydrogen Fueling Station
- **2021** Tri-gen construction begins
- **2022** TLS LB Operations buildings complete, Heavy-Duty Fueling Station starts commissioning
- **2023** Tri-gen Commercial Operation Date in October, First Mirai fill with Tri-gen hydrogen in December
- **2024** May Grand Opening Event

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Tri-gen overview

- **FuelCell Energy** owns and operates Tri-gen
- **2.3 MW** Molten Carbonate Fuel Cell
- **Hydrogen and Power Purchase Agreement** (HPPA) with FuelCell Energy
    - **1,200 kg** hydrogen production capacity per day
    - Electricity production to meet **TLS Long Beach operations** demand ~ 400 kW (balance of power sold to **local electric utility**)
    - Electricity cost is **almost half** of what electric utility charges, **lower cost** Hydrogen
    - Tri-gen power for **TLS will island** in the event of grid outage
    - **5,540 liters** (1,440 gal) water production capacity per day (supplements water for car wash)
  - FCE 2-year **Renewable Natural Gas** (RNG) contract for **biogas** generated from **organic waste**
  - Commercial Operation Date: **October 2023**
- Hydrogen **fueling and** Battery Electric Vehicle (BEV) **charging:**
    - Imported **Mirai** processing
    - HD **Fuel Cell Truck**
        - **10** PACCAR Class 8 **Fuel Cell Trucks** on order for TLS
        - **20** PACCAR Class 8 **Fuel Cell Trucks** on order for Parts Delivery

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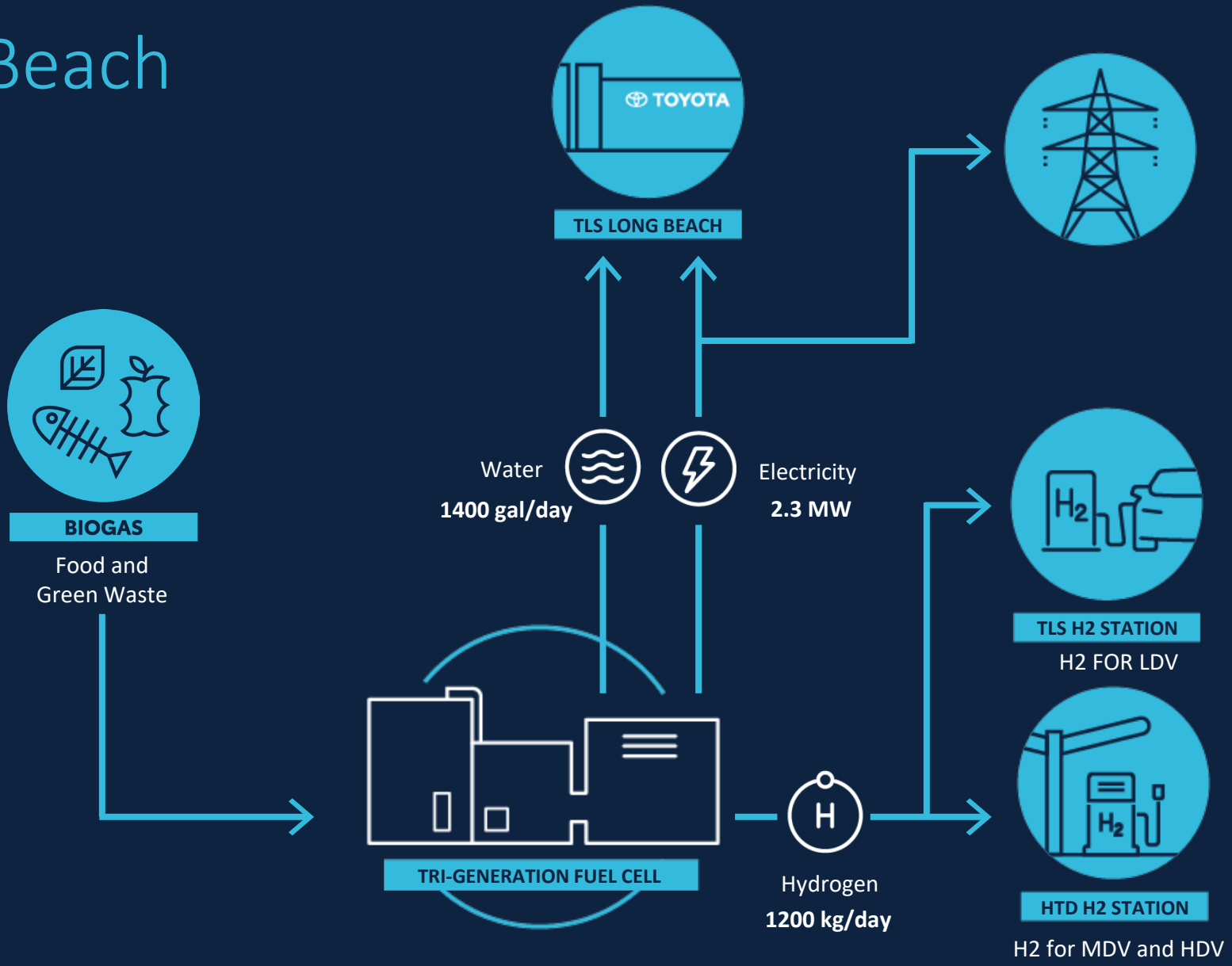
TLS Long Beach



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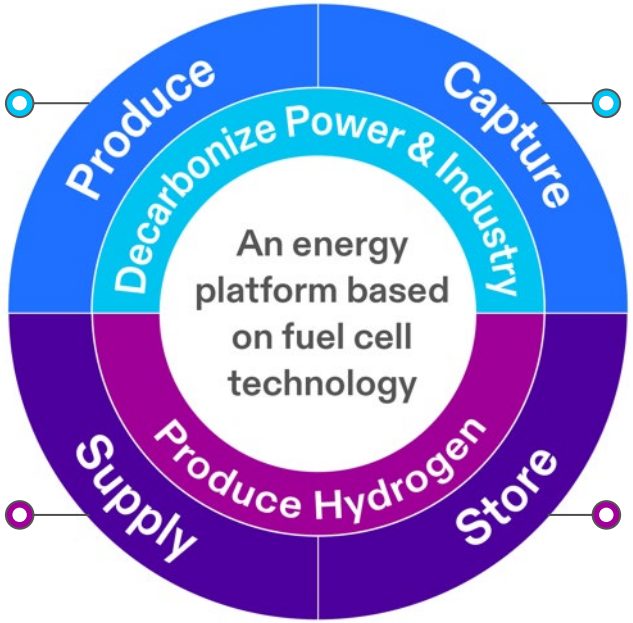
FuelCell Energy: A global leader in fuel cell technology

Employees	~600
Modules in operation	188
U.S. patents covering our fuel cell technology	158
Years operating in Connecticut	55
Millions of MWhs generated with patented technology	15
Continents with customers including Asia, Europe, North America	3
Game changing high-temperature electrochemical platforms	2
First in the world to produce hydrogen, electricity, and water in a single system	1

Produces low-to-zero carbon power with flexible fuel options including biogas, natural gas and hydrogen.

Supplies hydrogen through our electrolyzer with up to 100% efficiency; or co-produces hydrogen, power and water from biogas or natural gas with our Tri-gen system.



Only known technology in the world that can capture CO_2 (for use or sequestration) while making power.

Converts excess power from renewables to hydrogen, then converts hydrogen back into power when it's needed.

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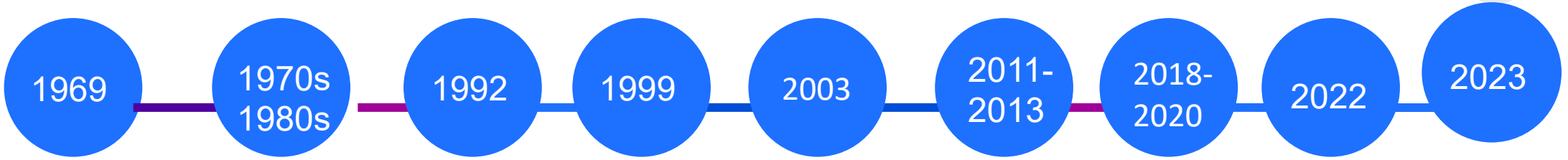
FuelCell Energy History



1969 — Bernard Baker and Martin Klein found "Energy Research Corporation" to focus on fuel cells and rechargeable batteries.

1970s 1980s — Energy Research Corporation evolves focus on carbonate fuel cell development *

1992 — The Company is publicly listed. Currently on NASDAQ as FCEL.

1999 — Company renamed FuelCell Energy and spins off its battery efforts to a separate company.

2003 — First commercial carbonate fuel shell shipment

Solid oxide development begins*

2011-2013 — First Tri-gen plant at Orange County Sanitation Department*

15MW Bridgeport and 59MW S Korea fuel cell parks

2018-2020 — Solid oxide fuel cell and electrolysis demonstrations*

2022 — Solid oxide fuel cell and electrolysis products launched

2023 — First Tri-gen launched at Toyota Logistics Center at the Port of Long Beach.

*Department of Energy-supported milestones

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Energy transition solutions based on two platforms

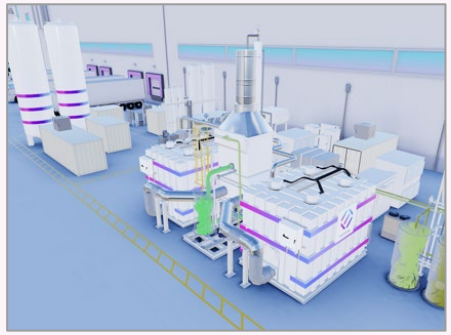
Carbonate

Power Generation

Reliable on-site clean power and heat recovery

Carbon Recovery + Capture

On-site CO_2 supply and clean power



Tri-gen

Generate hydrogen, electricity, and water

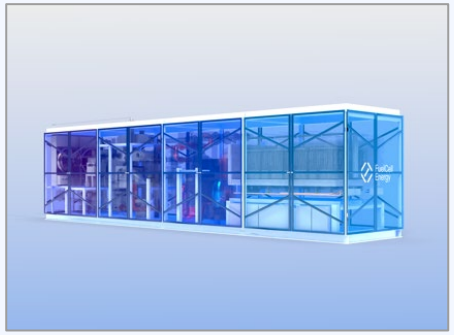
Solid Oxide

Power Generation

Reliable on-site power, fuel flexible, scalable solutions

H_2 Electrolysis

Superior efficiency, operational flexibility, scalable solutions



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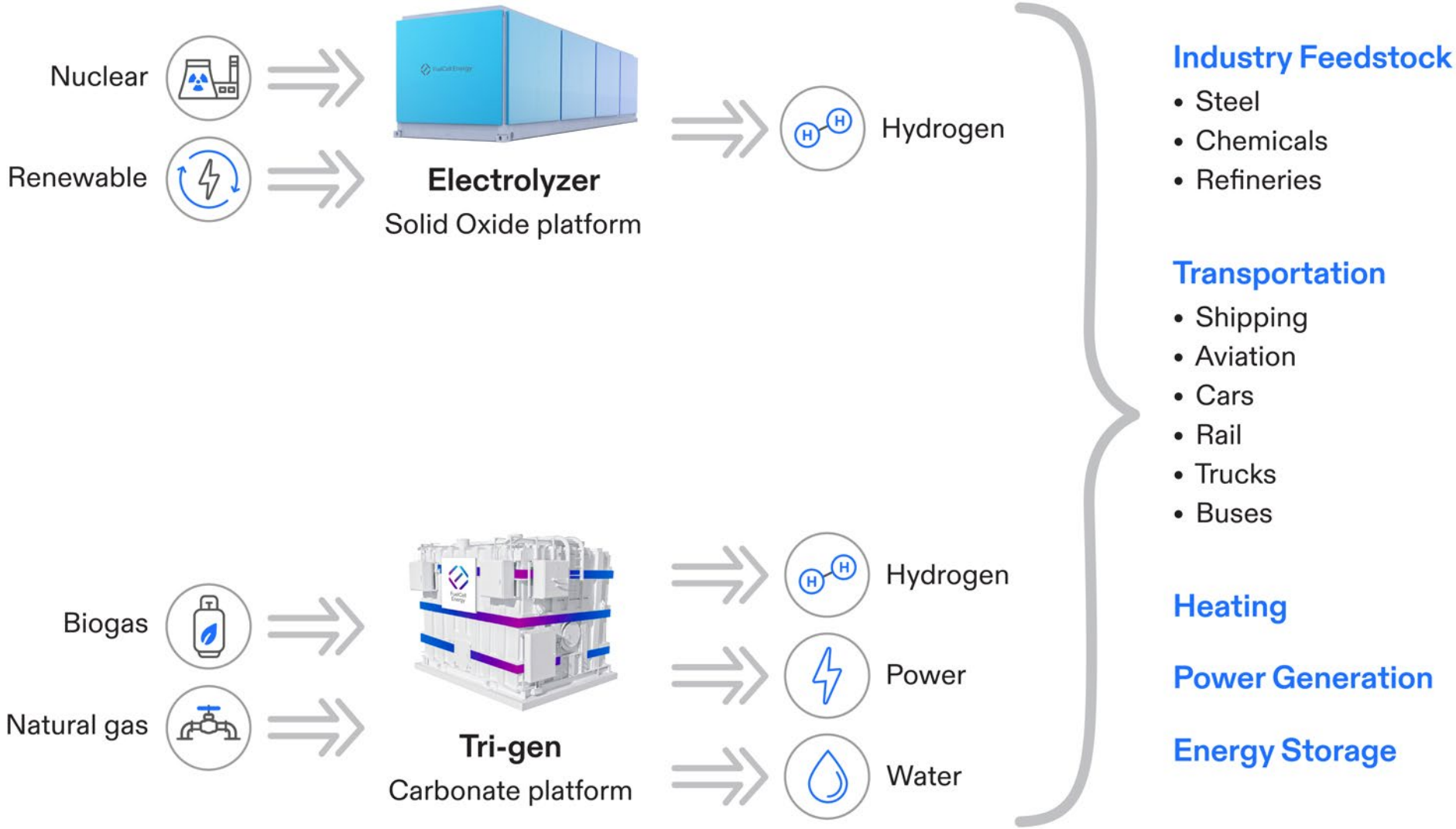
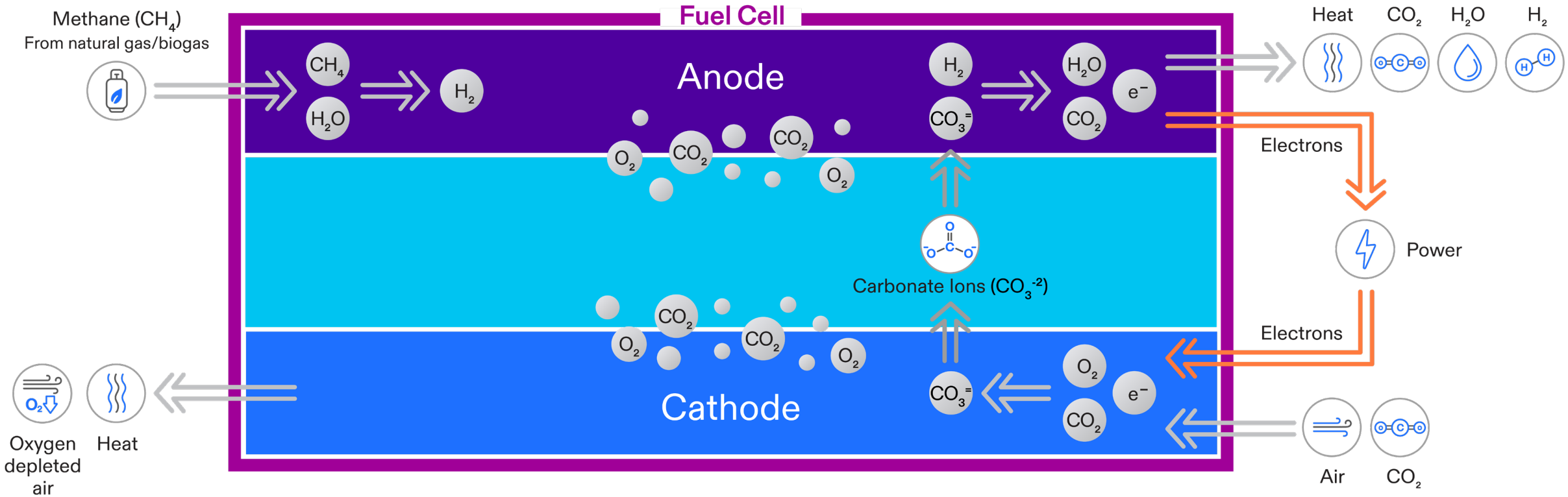
FuelCell Energy's two hydrogen solutions



How a fuel cell works



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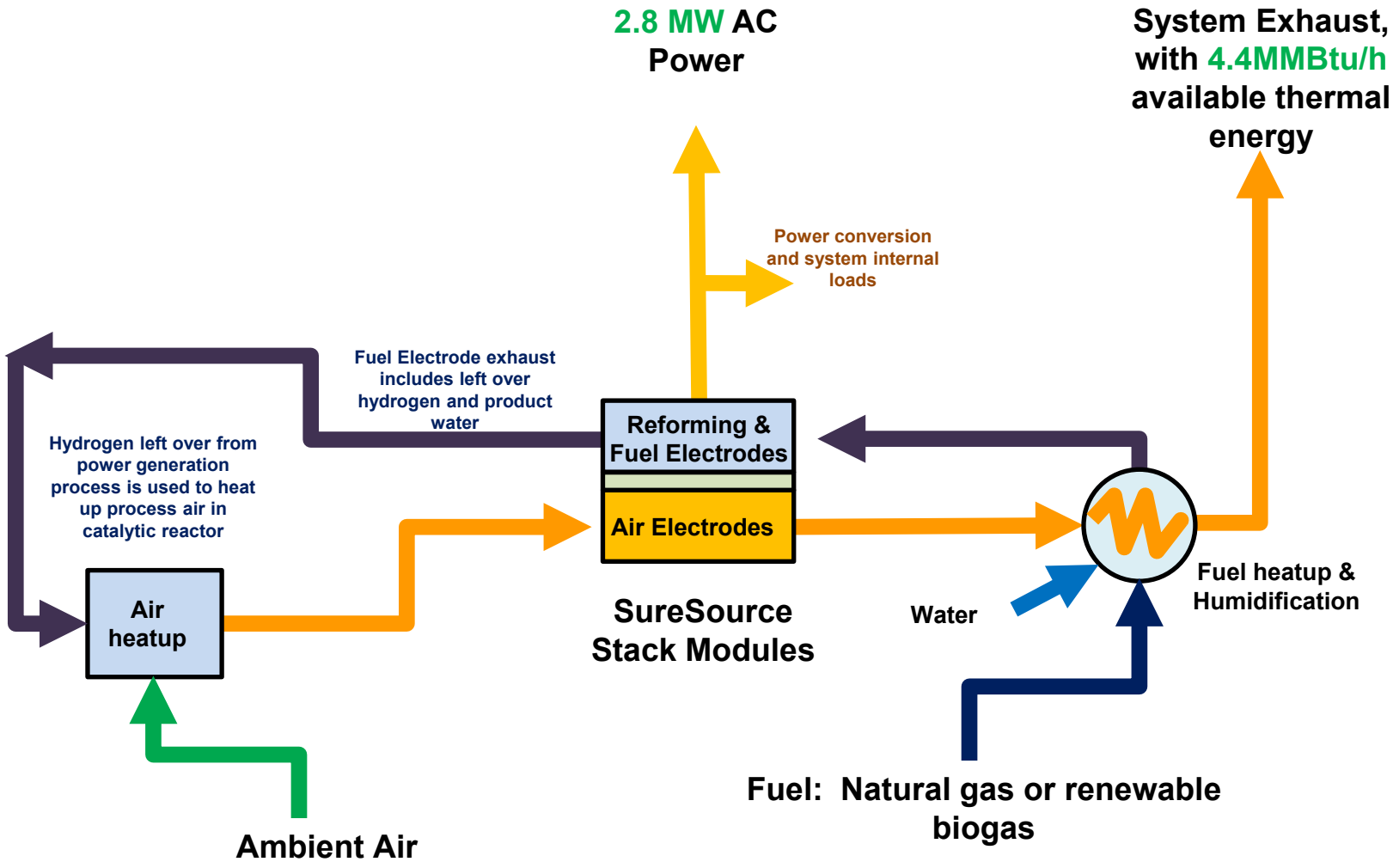
Carbonate fuel cell process overview



Hydrogen is produced from internal reformation of methane-based fuel, and used to make power and heat process air for fuel cell reaction

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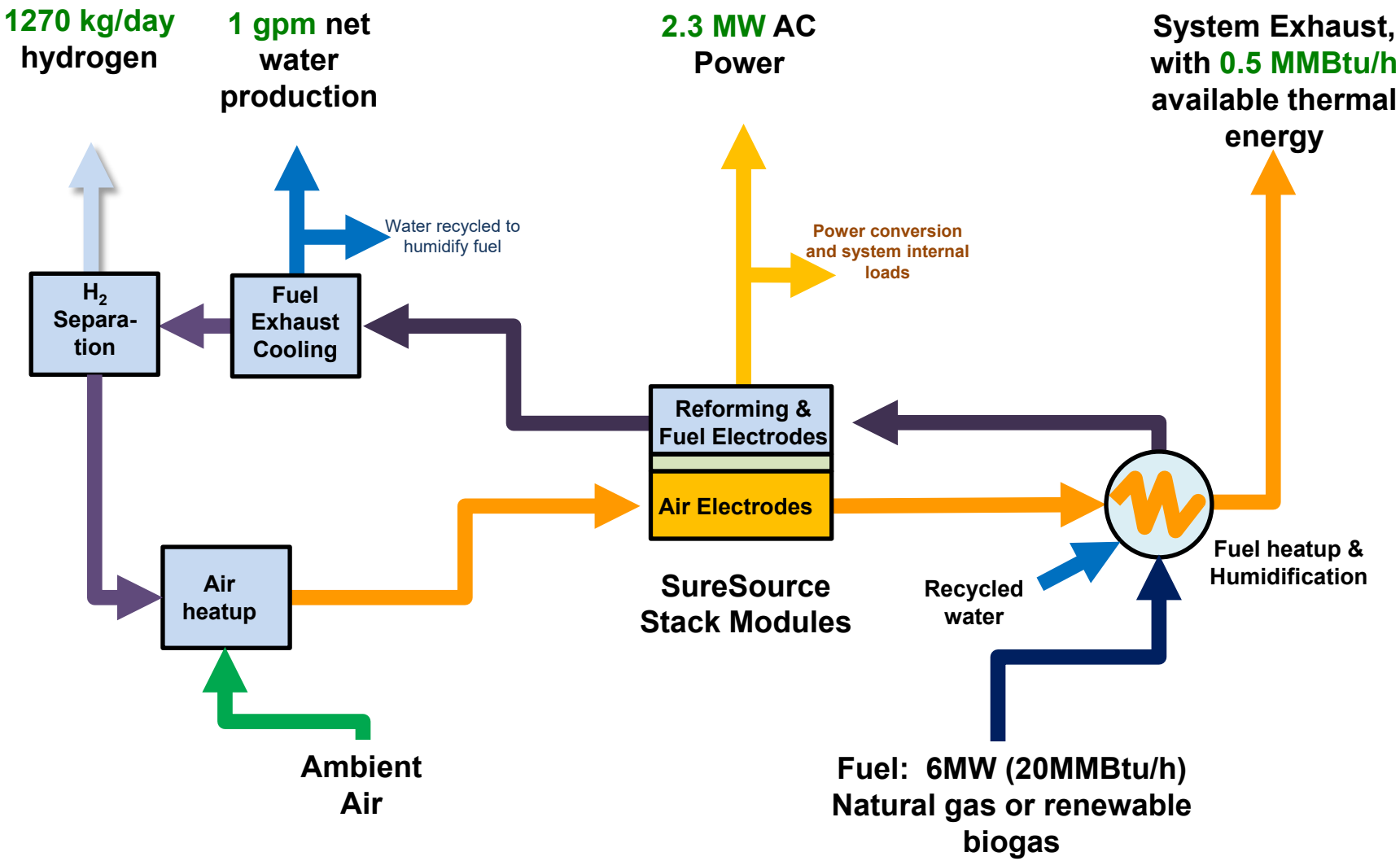
Tri-gen process overview



Hydrogen is produced from methane in the fuel cell stack modules, using fuel cell product water and waste heat to support reforming

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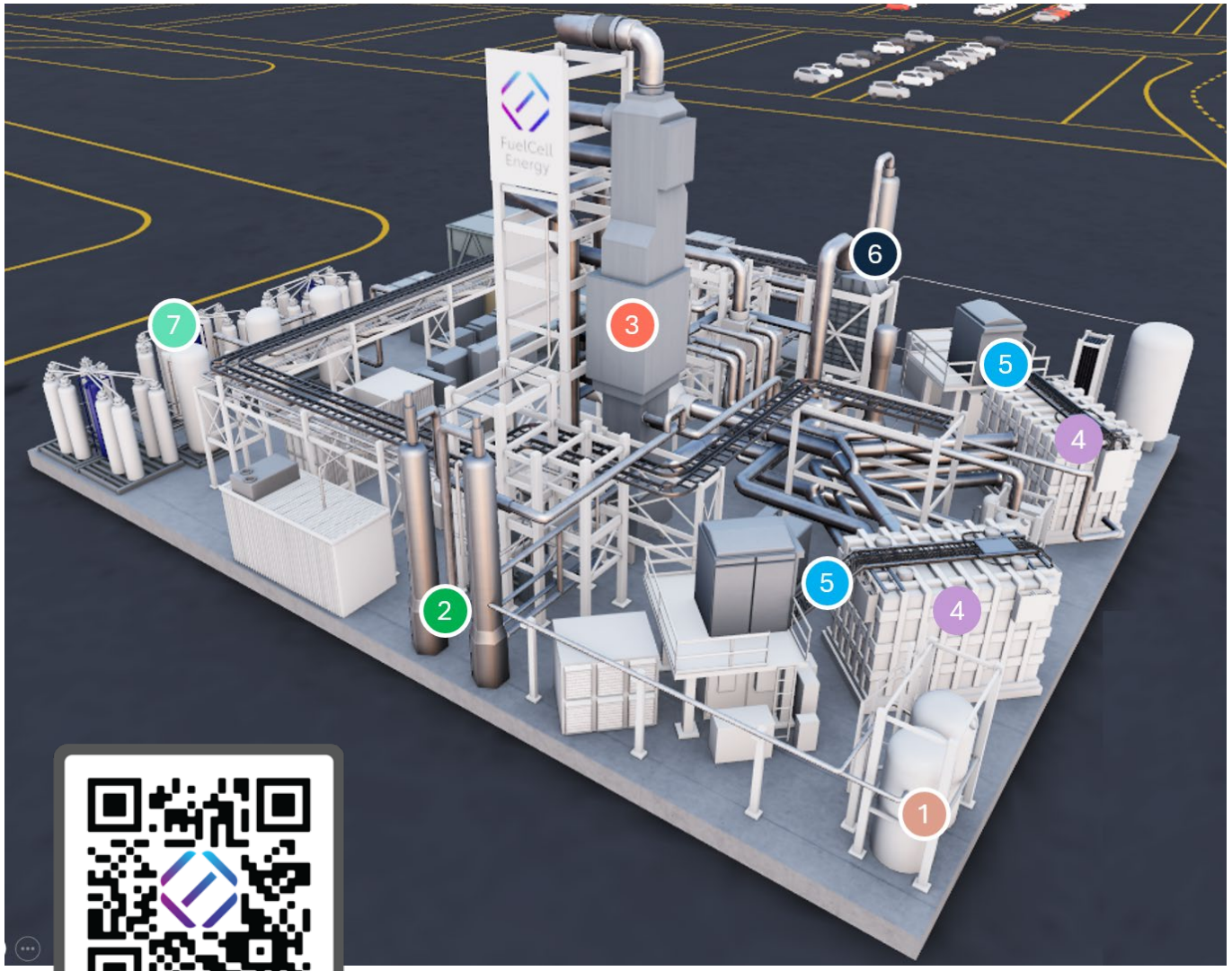
Tri-gen system components

1. **Inlet:** Directed biogas from adjacent pipeline
2. **Gas saturation:** Wetting gas to ideal water/methane ratio for reforming
3. **Pre-heating:** Transfer of heat from fuel cell exhaust to incoming process streams
4. **Fuel cell reforming:** Heat and water from fuel cell power generation used to reform gas to produce H2
5. **Power generation:** From fuel cell, inverted from DC to AC
6. **Water recovery:** Cooling of gas leaving fuel cell for water vapor recovery and re-use
7. **Hydrogen purification:** H_2 purified to SAE specification for fuel cell vehicle use



3D Tour

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Tri-gen sustainability benefits

Biogas

Natural gas

2.35 MW Clean and renewable power – 18 GWh/year

- 1200 tons per year avoided grid CO_2 emissions with natural gas fuel
- 10,000 tons per year avoided grid CO_2 emissions with biogas fuel
- 5 tons per year avoided NOX

0.5 MMBtu/h thermal energy

- 290 tons per year avoided boiler CO_2 emissions
- 200 lbs per year avoided NOX

1270 kg/day hydrogen

- 1700 tons per year CO_2 reduction vs SMR
- 4200 tons per year CO_2 reduction vs SMR with biogas fuel
- 700 lbs per year NOX reduction vs SMR
- 2 million gallons less water used per year vs SMR

1400 gallons / day water

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Fountain Valley, CA demonstration project

World's first Tri-gen project

- 3-year demonstration project at the Orange County Sanitation District water recovery plant, Fountain Valley, CA
- On-site biogas fuel
- Renewable power and hydrogen
- Rated output: 250kW; 100 kg H_2/day
- Hydrogen supplied to on-site vehicle fueling station
- Operated on site from late 2010 to mid 2014

Project Participants:

- US Department of Energy, Office of Energy Efficiency and Renewable Energy, HFTO
- FuelCell Energy
- Air Products
- Orange County Sanitation District
- Southern California Gas Company
- South Coast Air Quality Management District
- California Air Resources Board
- University of California, Irvine

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Distributed H_2: Tri-gen system at the Port of Long Beach

Toyota's first port vehicle processing facility in the world powered by onsite-generated, 100 percent renewable energy

- 2.3 MW of renewable electricity
- Up to 1200 kg/day of H2
- 1400 gallons of water/day

> 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

TOYOTA

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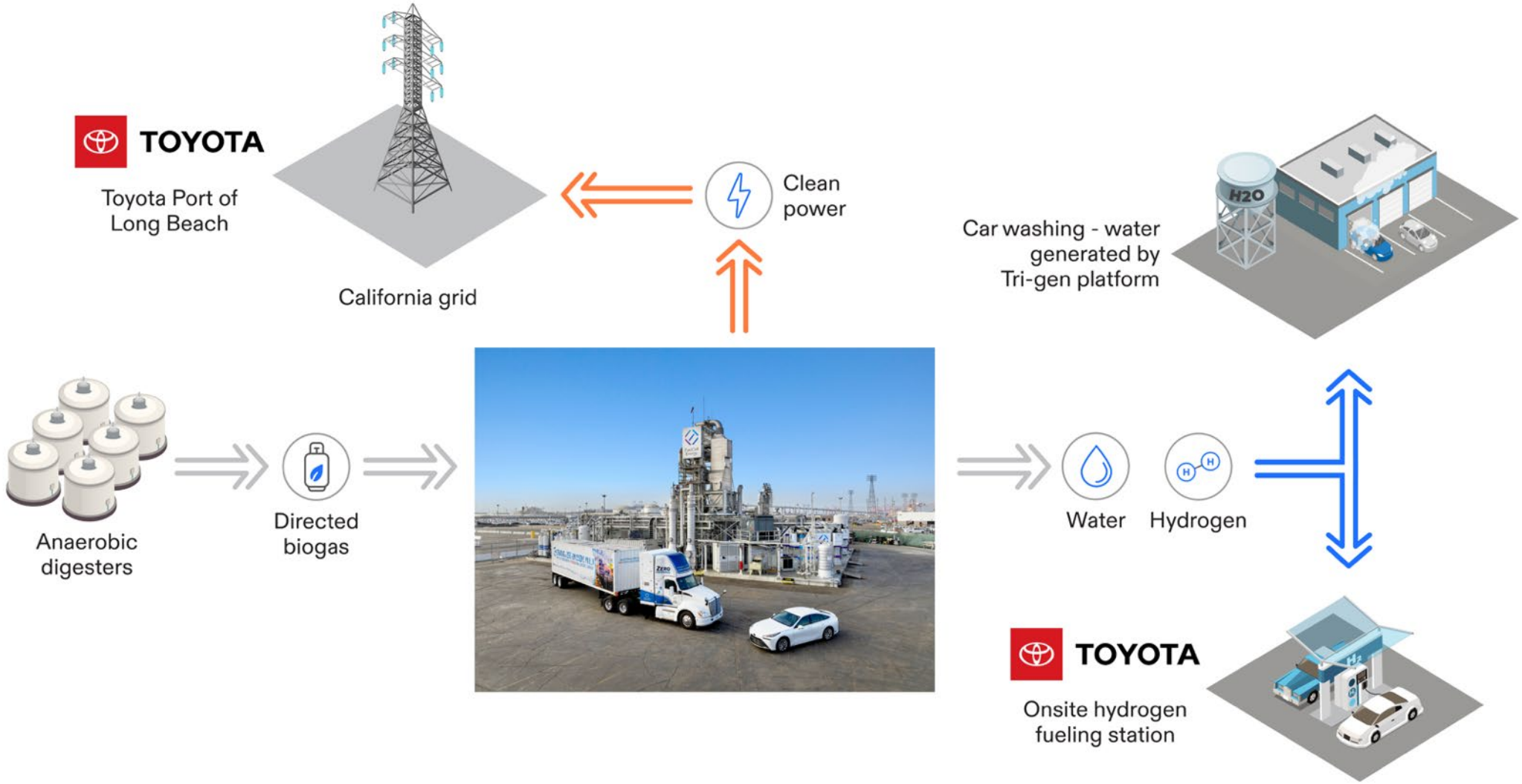
Distributed H_2: Tri-gen system at the Port of Long Beach



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Thank you!

3D Tour

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