



Capstone®

Turbine Corporation



# Capstone & The Renewable Future

Jim Crouse

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**Reliable power when and where you need it.  
Clean and simple.**

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# Capstone Customer Benefits



## DID YOU KNOW?

In **FY19**, Capstone customers benefited from:

**95.6%** in Global Availability

**350,000 Tons** in Carbon Savings

**\$253 Million** in Financial Savings



# Low Carbon CHP/CCHP Fuels



- Need for Carbon Reduction is Clear
- CHP and CCHP Operating on Natural Gas Reduces Carbon Intensity of Commercial and Industrial Customer
- Companies are Looking for Additional Reduction Through the Use of Low Carbon Fuels
- Some are Available Today
  - Landfill Gas
  - Biogas
- Some are Beginning to Emerge in the Market Place
  - Hydrogen
  - Methanol
- Some Require New Capstone Products
  - Hot Air Microturbine
    - Solar
    - Biomass
  - Hydrogen Microturbine
  - Methanol Microturbine





# Biogas/Biomethane



## How Biogas Systems Work



**Manure**  
(e.g., dairy, swine, beef, poultry)



**Wastewater Biosolids**  
(e.g., municipal sewage sludge)



**Food Waste**  
(e.g., household, restaurant, cafeteria, grocery, food production)

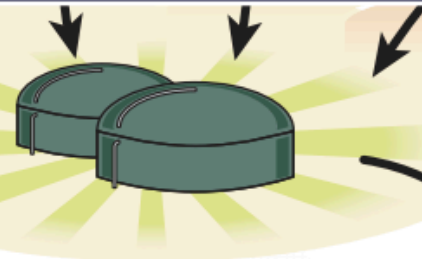


**Other Organics**  
(e.g., energy crops, fats, oils, grease, crop residue, winery/brewery waste)



**Organic Material**

Microbes break down organic material over 2-4 weeks producing biogas and digestate



Digested material may be returned for livestock, agricultural and gardening uses



**Bioproduct Feedstock**  
(e.g., bioplastics)



**Biogas**

Some biogas can be used to heat the digester



**Digested Material**



**Horticulture Products**  
(e.g., soil amendment, peat moss replacement, plant pots)



**Electricity**



**Renewable Natural Gas**



**Vehicle Fuel**



**Heat**



**Soil Products**



**Animal Bedding**



**Other Products**  
(e.g., building material)



**Crop Irrigation**

# Biogas/Biomethane



- Biogas is produced from anaerobic digestion of organic matter.
- Currently capturing only 2% of global potential with full capture potentially reducing GHG emissions by 3-4,000 Mt CO<sub>2</sub> eq. (or 10-13% of current global GHG emissions).<sup>1</sup>
- Common Applications:
  - Farm Digesters
  - WWTP
  - Landfills
  - Transportation Fuel
  - Upgrade for Pipeline Injection



<sup>1</sup>World Biogas Association, "Global Potential of Biogas." September 2019

# Biogas/Biomethane



## Benefits:

- Reduced greenhouse gas emissions through fuel substitution and reduction of uncontrolled methane emissions
- Baseload renewable energy source with ability to store for later use with intermittent generation resources
- Production of natural fertilizer
- Better waste management to reduce odors, protect water ways and improve sanitation and hygiene
- Potential extraction of CO<sub>2</sub> for commercial use (greenhouses, etc.)
- Pipeline injection to “green” the pipeline through natural gas substitution



# Hydrogen



- Hydrogen sources:

- **Green** – production from renewable power using electrolysis to split water molecules
- **Brown** – steam reformation from methane using coal sources
- **Blue** – steam reformation from methane using gas sources



- Capstone activities:

- Capstone's high flame speed fuel injector patents target operation on liquid and hydrogen blend fuels and ensuring ultra-low emissions meeting EPA Tier 4 requirements for power generation.
- Argonne National Lab project to blend up to 50%  $H_2$  with natural gas using current injector operating from partial to full load. Then use new patented injector to test blends over 50%  $H_2$ .
- UC-Irvine and SoCal Gas project to test blending up to 20%  $H_2$  with natural gas.



# Innovative Power Plant with Renewables



WIND



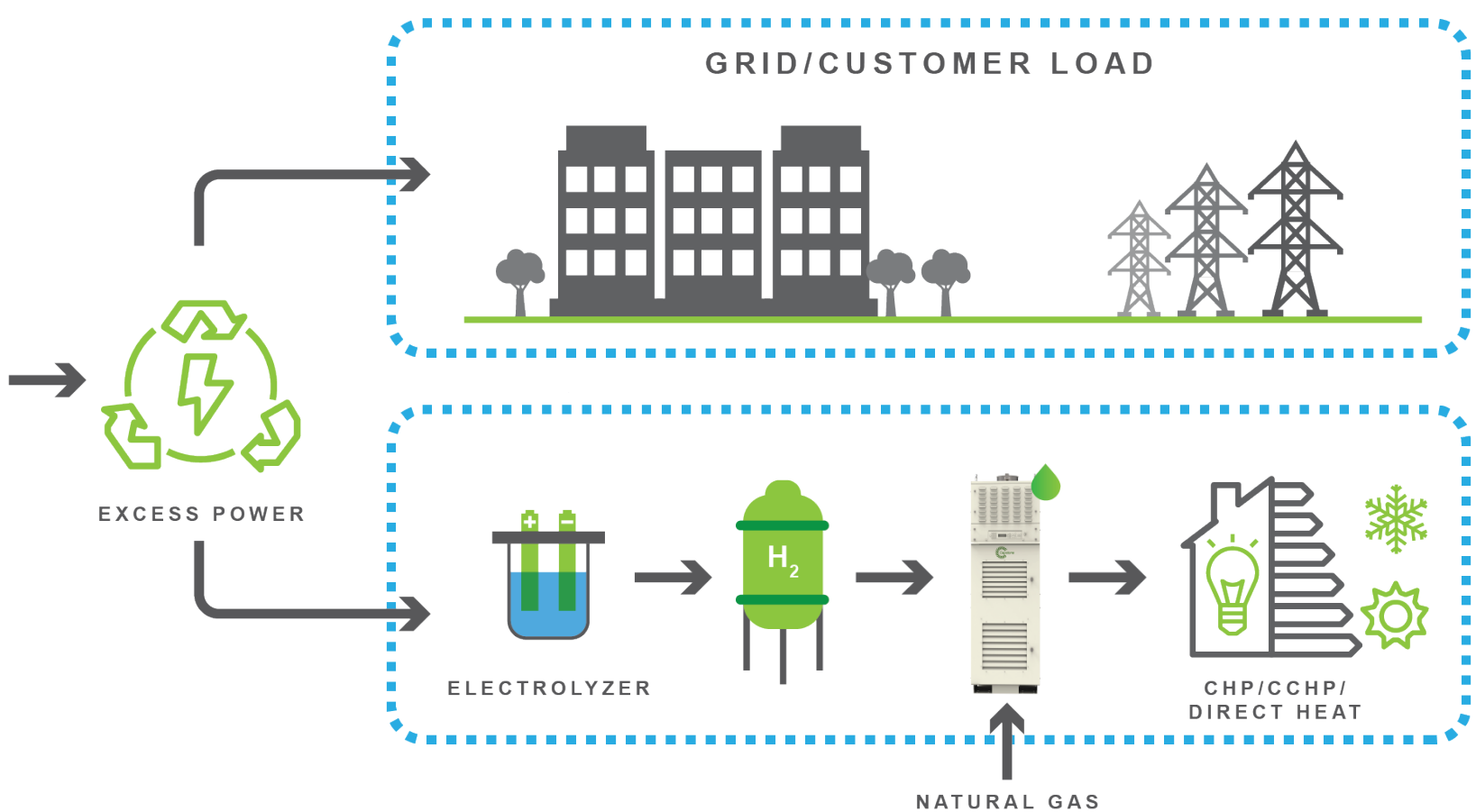
SOLAR



BIOGAS



HYDRO





# Biomass



- Convert a variety of waste products (e.g. industrial wood waste, sewage sludge) to heat and power through combusting waste to create compressed air to run the microturbine.
- Benefits:
  - Decentralized on-site disposal and increased disposal safety
  - Sustainable waste management
  - Modular, fuel flexible, low maintenance



# B+K | CHP Solutions



- Another 100% renewable project is with a German company, B+K, that is using wood waste to generate superheated air and also expanding it across the Capstone microturbine. B+K has been operating a Capstone powered pilot project for more than a year and is moving into commercial sales, with several projects planned in 2020.

## B+K





# 247Solar



- Modular Concentrated Solar Power (CSP) plant where solar receiver heats airflow, which then drives the microturbine to produce electricity. System is paired with brick/ceramic thermal energy storage to allow continuous operation when solar is unavailable.

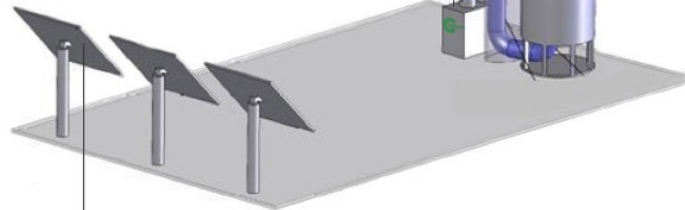
## 247SOLAR



**4) Capstone Microturbines**  
(Off-the-Shelf, 300-400 kWe, outfitted with 247Solar Heat Exchanger™)



**1) Off-the-Shelf**  
Sun-tracking Heliostats  
(~4 acres per 400 kWe)



Sunlight from Heliostats

**3) Conventional**  
Tower System  
(~125ft (35m), not shown)

Air Flow - warm air up, hot air down

**2) Highly Innovative**  
247Solar Receiver™  
(air heating, no moving parts)



**5) 100+ Year Proven**  
247Solar Thermal Storage System™  
(4-15 hours, e.g. fire brick no moving parts)





## ■ Status:

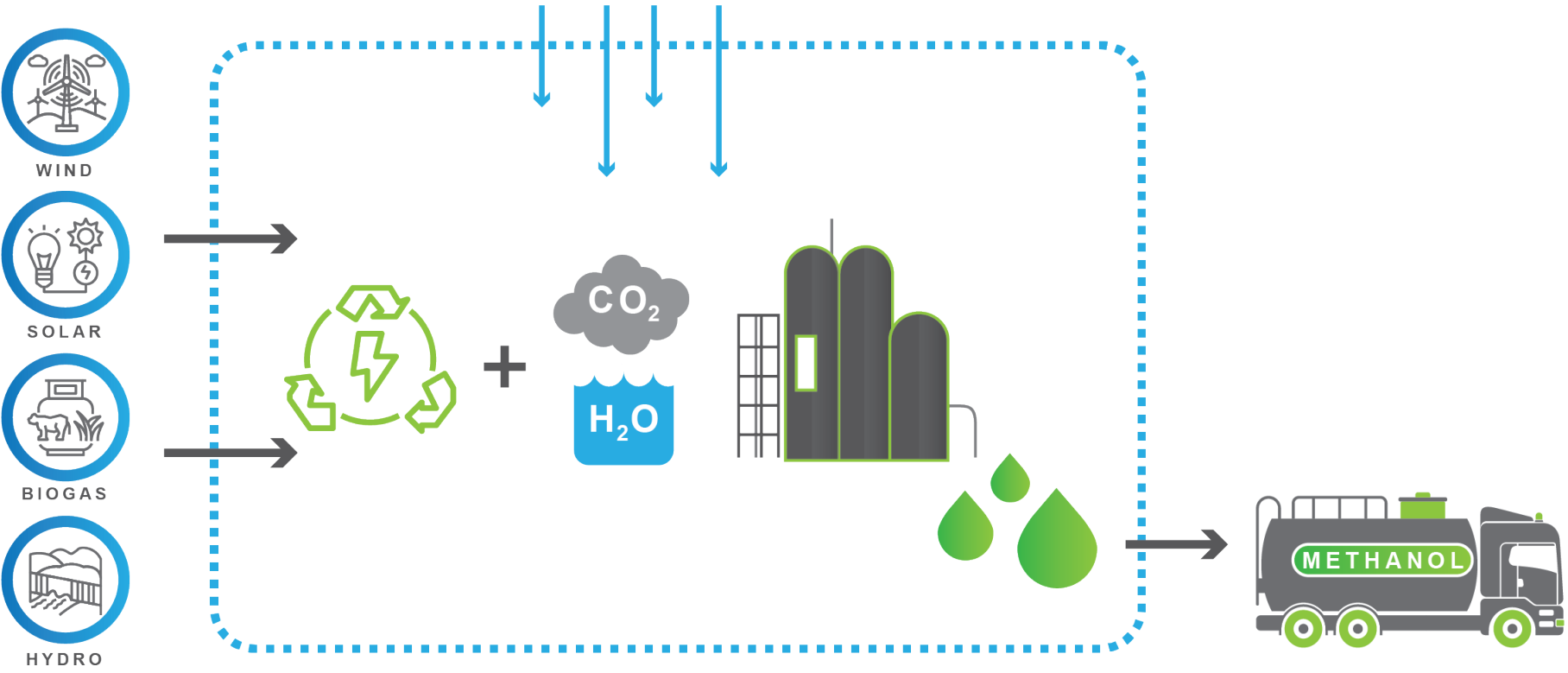
- First operational CSP demo plant planned for Morocco in partnership with Masen



## ■ Benefits:

- Deployable as single off-grid system of 400 kW plus 1.5 million btu/hr of useful heat or utility scale farms
- Round the clock operation regardless of weather
- Off-the-shelf, best-in-class equipment
- Pre-engineered, standardized for fast assembly on site
- No known environmental drawbacks
- Ability to burn a variety of fuels to guarantee electricity on demand eliminating need for additional emergency backup

# Zero Carbon Methanol



# Zero Carbon Methanol CHP







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