Advanced Manufacturing Office Trends in CHP

Bob Gemmer
AMO CHP Team, Technical Partnerships

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U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

DOE Priorities: Deploying the Clean Energy Revolution

BIDEN ADMINISTRATION CLIMATE GOALS

A carbon pollution-free power sector by 2035

Net-zero emissions by 2050

Make basic science breakthroughs

Turn that science into deployable technologies

Fund deployment of clean energy technologies

- **CREATE GOOD-PAYING JOBS**
  associated with the fast-growing global market for products that reduce carbon emissions
- **COMMIT TO RACIAL JUSTICE**
  and target disadvantaged communities for new clean energy investments, jobs, and businesses
- **ENCOURAGE ROBUST COLLABORATION**
  across the federal government, the fifty states, and the private sector

Industrial Organization Network (ION)

Goal:

A program that promotes deeper engagement between AMO and non-manufacturing industrial community

- Open to trade associations, NGOs, vendors, utilities
- Partners inform AMO Technical Partnership programs and receive recognition

CHP TAPs: Current Engagement

Program Activities

- Deliver trainings to stakeholder groups and associations
- Participate in end-user networks and organization events
- All activities are tracked and recorded by CHP TAPs
- Packaged CHP Accelerator has 12 utility partners

Target Audience

- Utilities, SEOs, and regional trade associations

Benefits

- Increased awareness of CHP TAP resources and TA opportunities
- Networking with companies and organizations interested in CHP
- Higher adoption of CHP across different sectors

CHP TAP Stakeholder Activities (FY19-20)	Total
Engineer/Developer Education	26
Interconnection	2
Legislation	20
Permitting	5
Portfolio Standard	7
Resiliency	21
Standby Rates	9
State Energy Plan	65
Utility CHP Program	30
Utility Ownership	3
Other	37
Total	**225**

DOE CHP Technical Assistance Partnerships

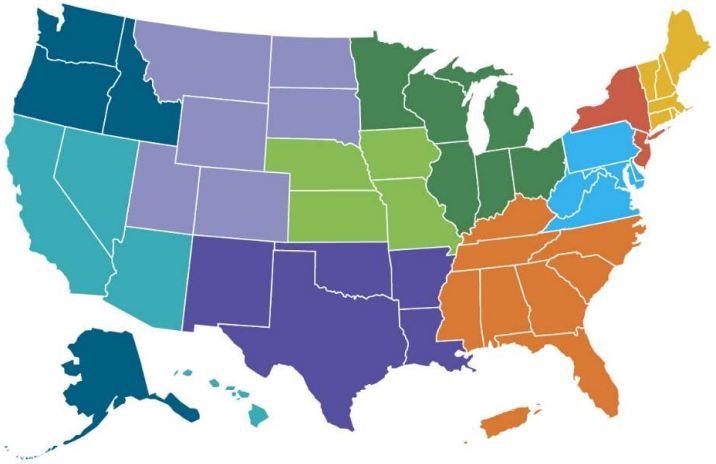
CHP Technical Assistance Partnerships

Upper-West
CO, MT, ND, SD, UT, WY
www.uwchptap.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.og

Midwest
IL, IN, MI, MN, OH, WI
www.mwchptap.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefke1@uic.edu

New England
CT, MA, ME, NH, RI, VT
www.nechptap.org
David Dvorak, Ph.D., P.E.
University of Maine
207-581-2338
dvorak@maine.edu

Northwest
AK, ID, OR, WA
www.nwchptap.org
David Van Holde, P.E.
Washington State University
360-956-2071
VanHoldeD@energy.wsu.edu



New York-New Jersey
NJ, NY
www.nynjchptap.org
Tom Bourgeois
Pace University
914-422-4013
tbourgeois@law.pace.edu

Western
AZ, CA, HI, NV
www.wchptap.org
John Woolsey
Center for Sustainable Energy
858-244-1187
john.woolsey@energycenter.org

Mid-Atlantic
DC, DE, MD, PA, VA, WV
www.machptap.org
Jim Freihaut, Ph.D.
The Pennsylvania State University
814-863-0083
jdf11@psu.edu

Southcentral
AR, LA, NM, OK, TX
www.scchptap.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.org

Central
IA, KS, MO, NE
www.cchptap.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefke1@uic.edu

Southeast
AL, FL, GA, KY, MS, NC, PR, SC, TN, VI
www.sechptap.org
Isaac Panzarella, P.E.
North Carolina State University
919-515-0354
ipanzarella@ncsu.edu

CHP Technical Assistance Partnerships Highlights:

FREE [illegible] D TECHNICAL ASSISTANCE

- 10 re[illegible]rs across the country.
- Fac[illegible]nformation to assist with trans[illegible]et for CHP technologies throughout the [illegible]
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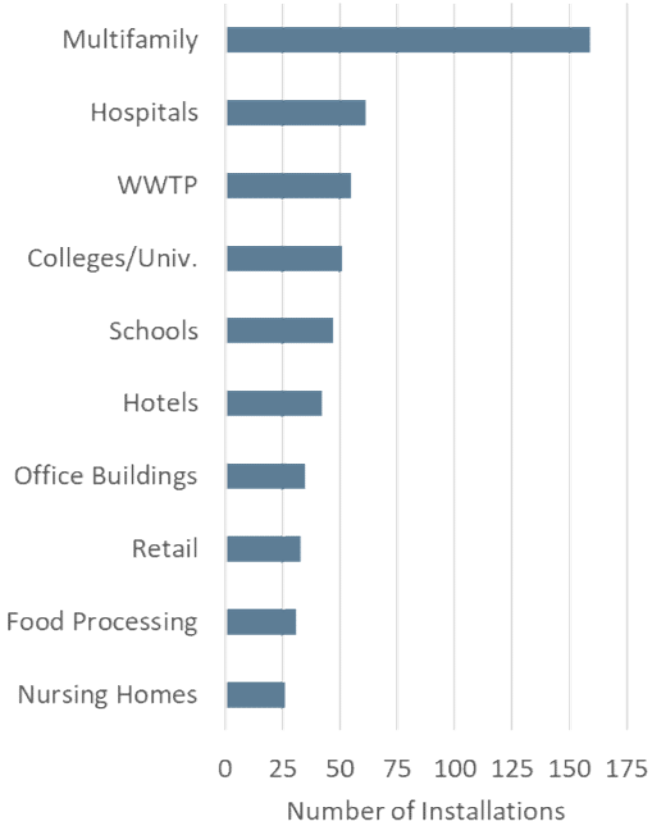
  - https://chp.ecatalog.lbl.gov/

CHP Market Trends – The Last Five Years

- Growing activity in non-traditional CHP markets (light industrial, commercial, institutional, multi-family) – 88% of installs
- Move toward smaller CHP installations – recip engines and microturbines make up 77% of installs
- Increase in packaged CHP system offerings
- Natural gas continues to be the dominant fuel - 67% of new capacity
- Renewable fuels increasing – 12% of new projects
- Resilience a key driver in critical infrastructure applications and microgrids
- Increasing interest in hybrid systems that integrate CHP with renewables and energy storage
- Growing push back on natural gas CHP

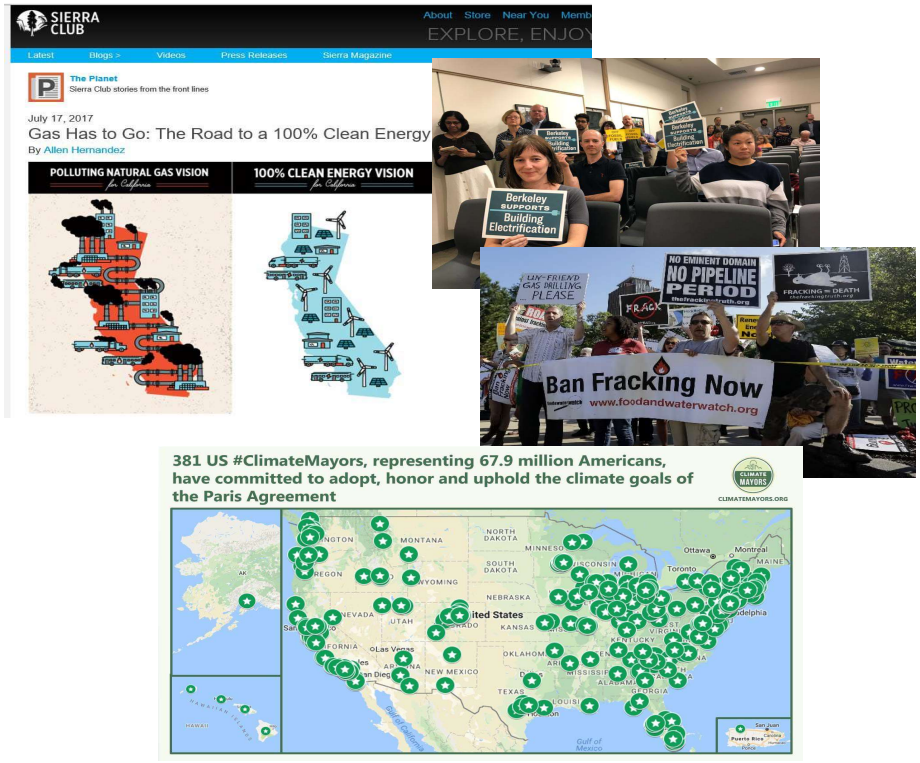
Top CHP Applications 2015-2019



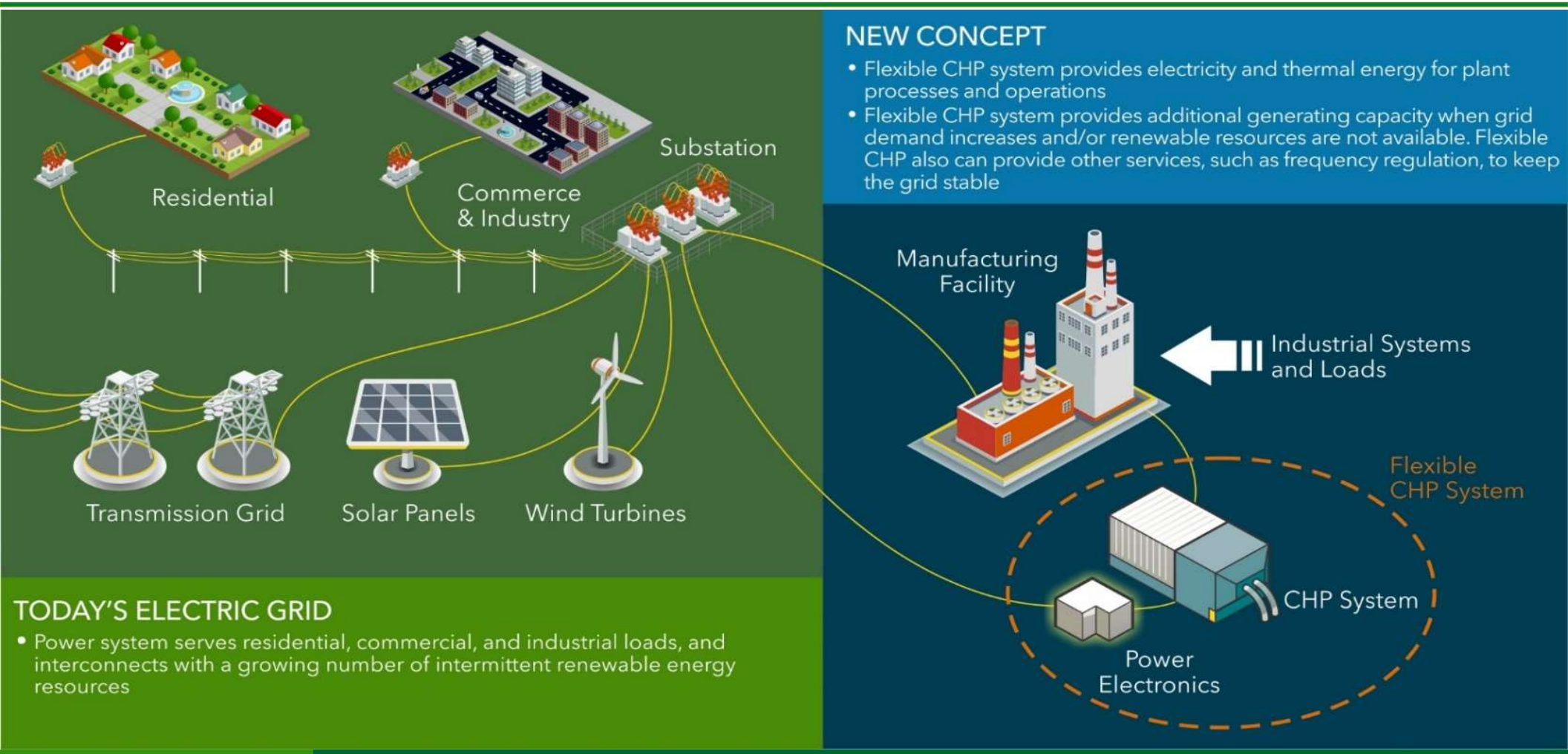
Source: DOE CHP Installation Database (U.S. installations as of August 31, 2020)

Flexible Combined Heat and Power Systems: Decarbonization

- Decarbonization is a major policy topic in many states and cities
  - Aggressive CO_2/greenhouse (GHG) reductions of 40% by 2030 and 80% by 2050
  - Focus on economy-wide electrification to get to net zero carbon
- Major push against natural gas in some areas
  - Over 20 cities in California and others in the Northeast have banned natural gas in new construction
  - Efforts to stop investment in natural gas infrastructure
    - Pipelines
    - Natural gas CHP



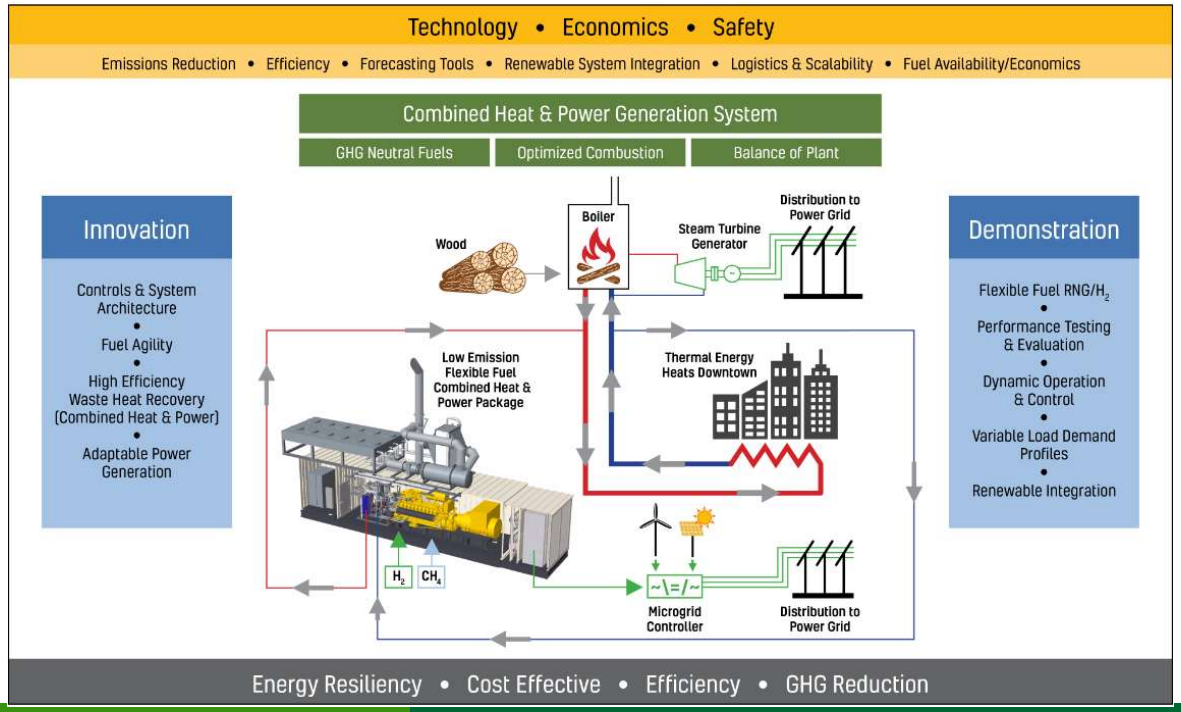
Flexible Combined Heat and Power Systems



Flexible Combined Heat and Power Systems: Caterpillar Example

Technology Summary

Caterpillar Inc. has teamed with The National Renewable Energy Laboratory and District Energy St. Paul to demonstrate a 2MW flexible natural gas/hydrogen combined heat and power (CHP) system at a municipal generating station. The project team brings together technical experts in combustion, engine design, hydrogen chemistry, energy conversion, and system integration with a leader in renewable energy for municipal CHP to develop and demonstrate a unique-to-the-industry power delivery and control system.



Key Personnel

Dr. David Todd Montgomery – Caterpillar
Michael Peters – National Renewable Energy Lab
Michael Burns – District Energy St. Paul

Program Summary

Period of performance:
36 months

Federal funds:	$4.55m
Cost-share:	$7.16m
Total budget:	$11.71m

	Key Milestones & Deliverables
Year 1	• Complete requirements documentation • Complete subsystem sizing and specification
Year 2	• Complete system layout and design • Complete bill of material
Year 3	• System commissioning complete • Final Report

Technology Impact

Caterpillar is a world leader in electric power products including engines, switchgear, and battery systems. This program will seed effort in adding natural gas/hydrogen flexible fuel CHP systems to the wide options space for stationary power applications.

RG Technologies and Feedstocks

- *Food Waste*
- *Animal manure*
- *Wastewater Treatment (WWTP)*
- *Landfill gas (LFG)*

- *Agricultural residue*
- *Forestry and forest product residue*
- *Energy crops*
- *Municipal solid waste (MSW)*

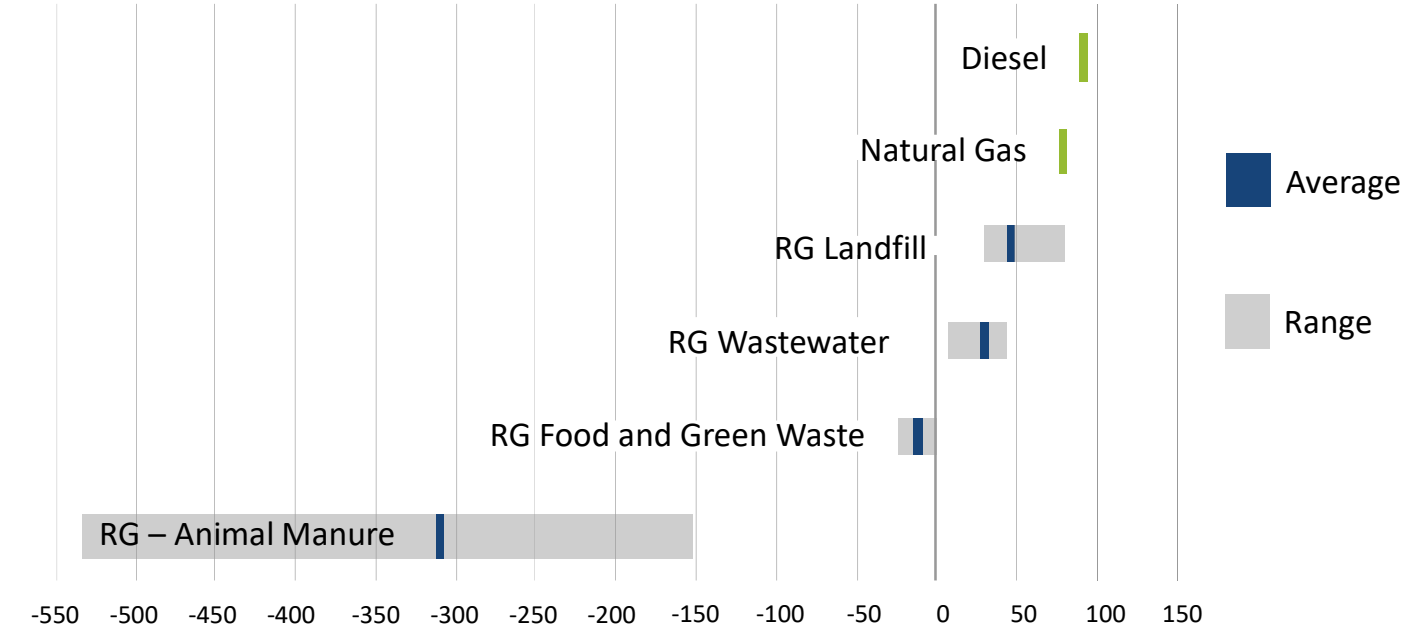
- *Green Hydrogen from renewable electricity*
- *Blue Hydrogen from natural gas with carbon capture*

Source: AGA Foundation, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, 2019

Carbon Intensities of RG Feedstocks

RG:

- Contributes to sustainable waste management
- Reduces methane from organic wastes
- Displays fossil fuels

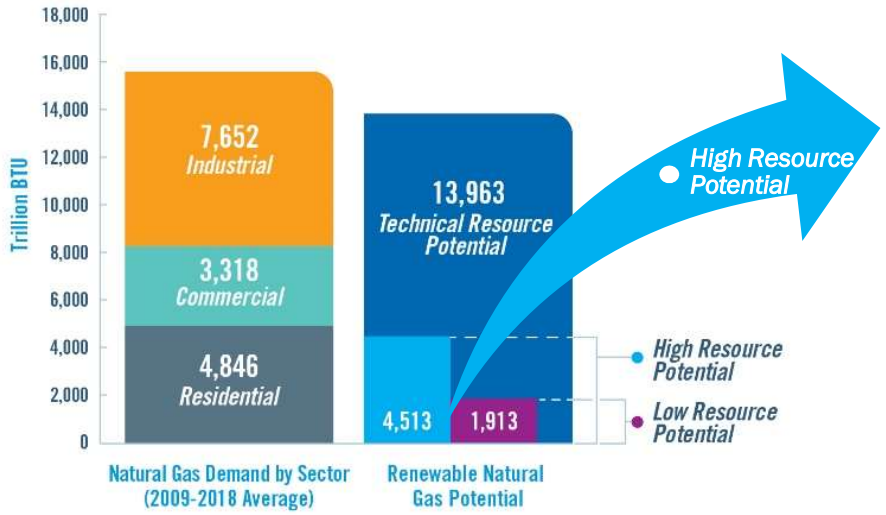


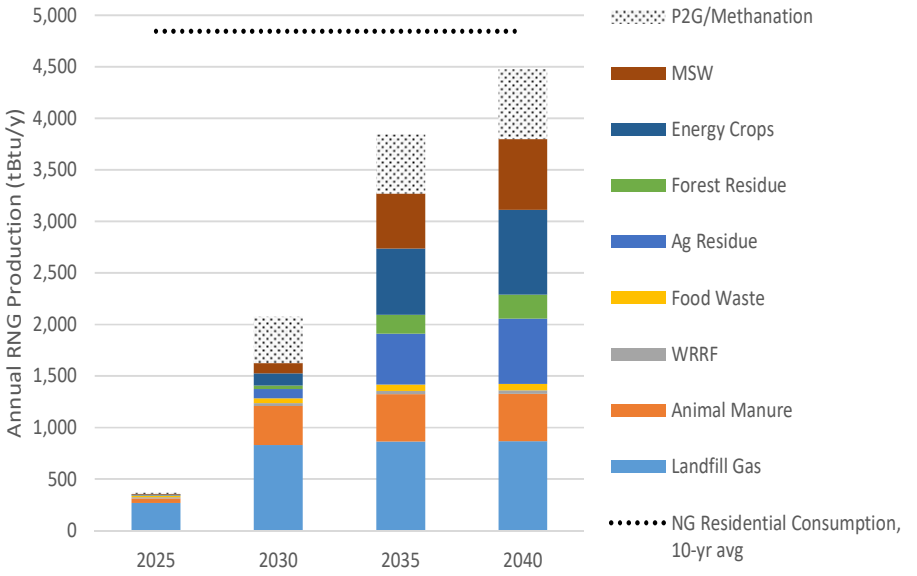
Carbon Intensity (g CO2e/MJ) – Current Low Carbon Fuel Standard Pathways

Source: WRI, Renewable Natural Gas As A Climate Strategy: Guidance For State Policymakers, 2021

RG Resource Potential

- High resource case: 4.5 Tcf of RG by 2040
- Represents 60% of industrial use of natural gas
- Cost competitive with other emission reduction strategies, $55-300/ton of GHG emission reductions





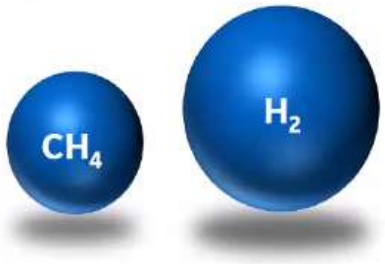
Source: AGA Foundation, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, 2019

Use of Hydrogen (H2) as a Fuel will Require System Changes

Use of hydrogen as a gas turbine fuel requires system changes

Fuel System

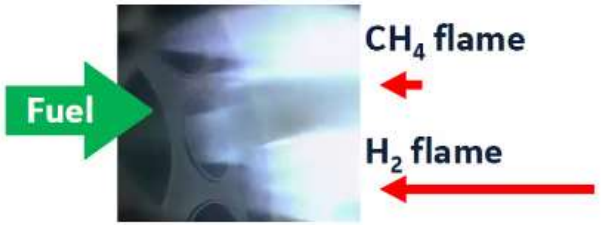
Methane (CH_4): 912 lb/ft^3
Hydrogen (H_2): 275 lb/ft^3



To deliver the same energy content, hydrogen requires 3X more volume flow

Combustion System

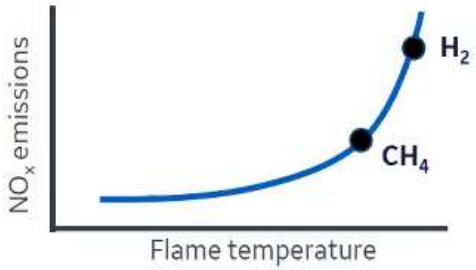
Methane (CH_4): ~30–40 cm/sec
Hydrogen (H_2): ~200–300 cm/sec



Hydrogen flames may increase risk of damage to combustion hardware

Emissions Aftertreatment

Methane (CH_4): ~3,565 °F
Hydrogen (H_2): ~4,000 °F



Operating on hydrogen may increase NO_x emissions

Operating a gas turbine on blends of hydrogen or on 100% hydrogen may require changes to key power plant systems, but this has been successfully demonstrated

Case Study: California's Self Generation Incentive Program

- State program to provide incentives for distributed generation projects to reduce peak energy demand.
- All gas generation technologies are required to blend a minimum amount of renewable fuel beginning in 2017.
- All projects applying after 2020 must use 100% renewable fuel.
- Generation projects earn $2.00/W + $0.60/W biogas adder.

Table 6.5.1: Minimum Renewable Fuel Blending Requirement

Application Year	% Renewable Fuel Required
2016	0%
2017	10%
2018	25%
2019	50%
2020	100%

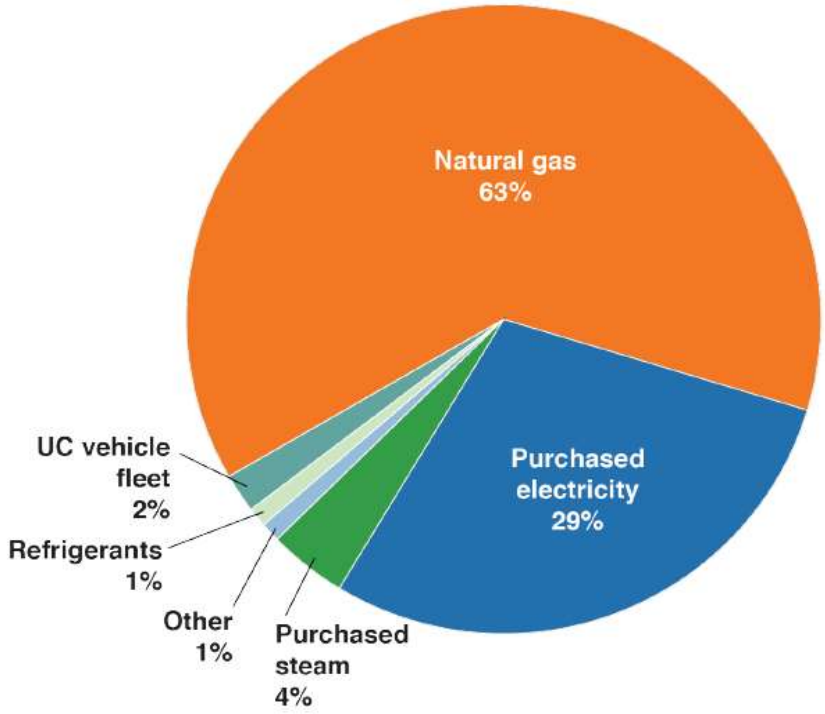
Self-Generation Incentive Program HANDBOOK, October 2, 2020, V.9.
Table 6.5.1: Minimum Renewable Fuel Blending Requirement

Additional Incentives to Consider

- Renewable Electricity Production Tax Credit (PTC). Option to claim Investment Tax Credit (ITC) in lieu of claiming PTC.
- Bioenergy Market Adjusting Tariff (BioMAT) – February 1, 2021 Prices:
  - Category 1 (WWTP) - $0.128/kWh
  - Category 2 (Dairy) - $0.188/kWh
- Low Carbon Fuel Standard
- Fuel Cells are NEM Eligible, but awaiting final CPUC decision

University of California GHG Emission Sources

- The UC System consists of:
  - 10 campuses
  - 5 medical centers
  - 3 national labs
- CHP at 7 campuses
- On-campus combustion of natural gas is primary decarbonization challenge

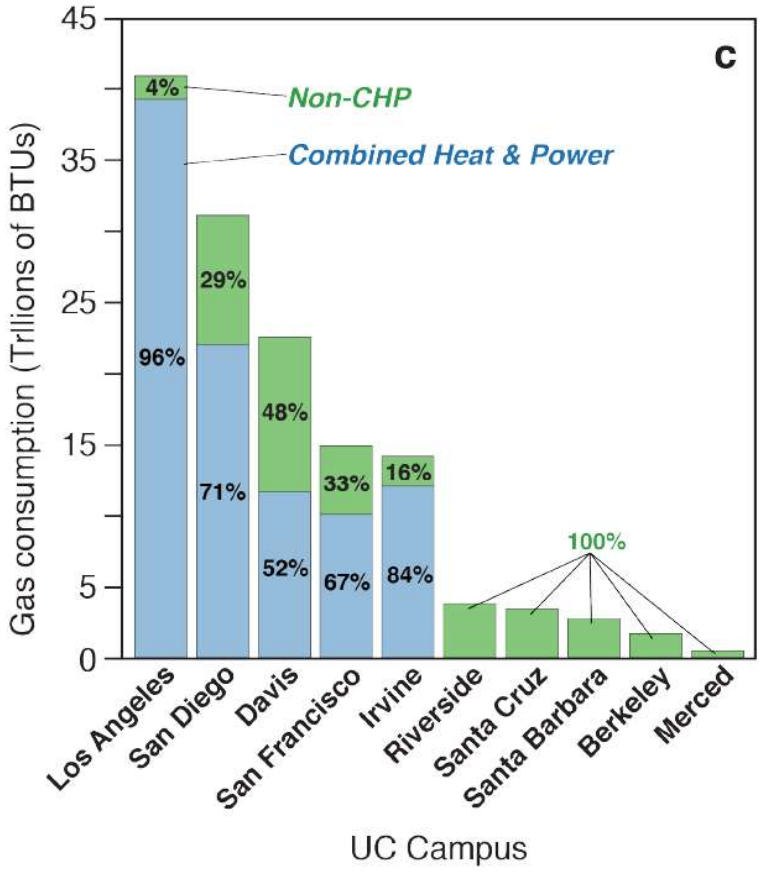


Source: University of California Strategies for Decarbonization: Replacing Natural Gas; TomKat Natural Gas Exist Strategies Working Group Report to the TomKat Foundation, February 2018

UC Natural Gas Consumption by CHP and Non-CHP Use

Note: Two campuses have CHP that are not reflected in the chart:

- UC Berkeley's CHP plant was owned & operated outside the UC system until 2017
- UC Santa Cruz's plant came online in 2016



Project Snapshot: UCSD Microgrid

University of California, San Diego (fuel cell installed in microgrid)
SOURCE: UCSD Triton Magazine

University of California San Diego
San Diego, CA

Application/Industry: University Campus
Capacity: 35.2 MW
Prime Mover: Two 13.5 MW gas turbines, 3 MW steam turbine, 2.8 MW fuel cell.
Solar PV: 2.4 MW array
Fuel Type: Natural gas for CHP / directed biogas for fuel cell.
Thermal Use: Domestic hot water, cooling water and electricity production.
Installation Year: 2001 for gas turbine, 2011 for the fuel cell.

Highlights:

- Trilogy has a Biogas Purification Plant at the City of San Diego Point Loma Wastewater Treatment Plant.
- 1.6 Million SCF/day of digester biogas is processed for injection into SDG&E natural gas pipeline and nominated to BioFuel Energy's fuel cells at UCSD and to San Diego South Bay Water Reclamation Plant.
- Fuel cell recovered heat used to drive a 350-ton absorption chiller for campus cooling.

Summary

- CHP is the most efficient way to generate power with any fuel
- CHP's high efficiency provides carbon reduction today.
- CHP systems can be fueled by a variety of fuels including green hydrogen and renewable gas.
- CHP's efficiency and resilience advantages will remain as RG and hydrogen use increase

The U.S. DOE CHP Technical Assistance Partnerships are available to:

- Provide screenings for technical and economic feasibility
- Provide third party reviews
- Provide technical assistance along the project path

Thank you

Questions?

For More Information:

Bob Gemmer
bob.gemmer@ee.doe.gov
202-586-5885 (desk)
202-251-8928 (cell)