Combined Heat and Power: A Solution for Data Center Energy Needs

Combined Heat and Power Alliance

May 11, 2023

Who We Are

- The CHP Alliance is a coalition of businesses, labor, contractors, non-profit organizations, and educational institutions with the common purpose to educate all Americans about CHP and WHP, and how CHP and WHP can make America's manufacturers and other businesses more competitive, reduce energy costs, enhance grid reliability, and reduce emissions.

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Columbia Gas® of Virginia
A NiSource Company

E-FINITY
Power to be Independent

ENGIE

SIEMENS energy

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Speakers


COMBINED HEAT AND POWER ALLIANCE
Webinar
Combined Heat and Power: A Solution for Data Center Energy Needs
THURSDAY, MAY 11
1 PM - 2:30 PM ET
Petrina Jones Wrobleski
Columbia Gas
David Lewis
Washington Gas
Tom Parker
Burns & McDonnell
Phil Reid
RED Engineering (ENGIE)
Buddy Rizer
Loudoun, Va. Economic Development
Pete Spicher
PSECU
Rich Sweetser
Mid-Atlantic CHP TAP

Webinar

Combined Heat and Power: A Solution for Data Center Energy Needs

Rich Sweetser
Department of Energy's Mid-Atlantic
CHP Technical Assistance Partnership

COMBINED HEAT AND POWER ALLIANCE

CHP: Reliability, Resilience, Decarbonization Opportunities for Data Centers

May 11, 2023

Richard Sweetser
Sr. Advisor
DOE Mid-Atlantic CHP TAP

Brief Overview

- DOE CHP TAP
- CHP Basics
- CHP in the U.S
- Packaged CHP System Design
- Emissions and Decarbonization
- Modeling 4 MW Electrical and Cooling System Design
- Questions

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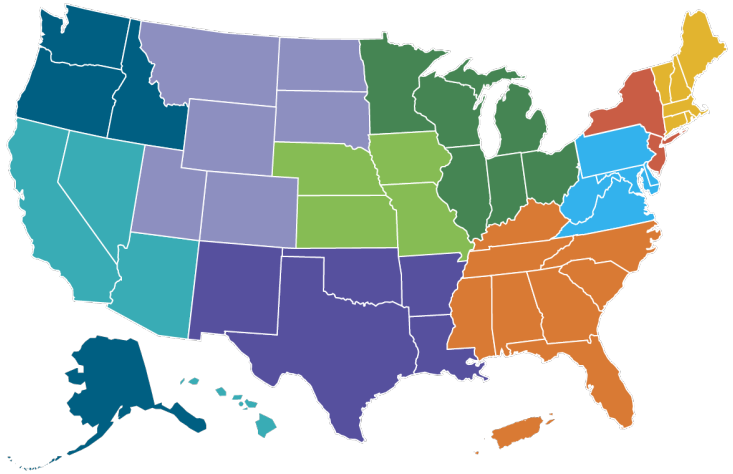

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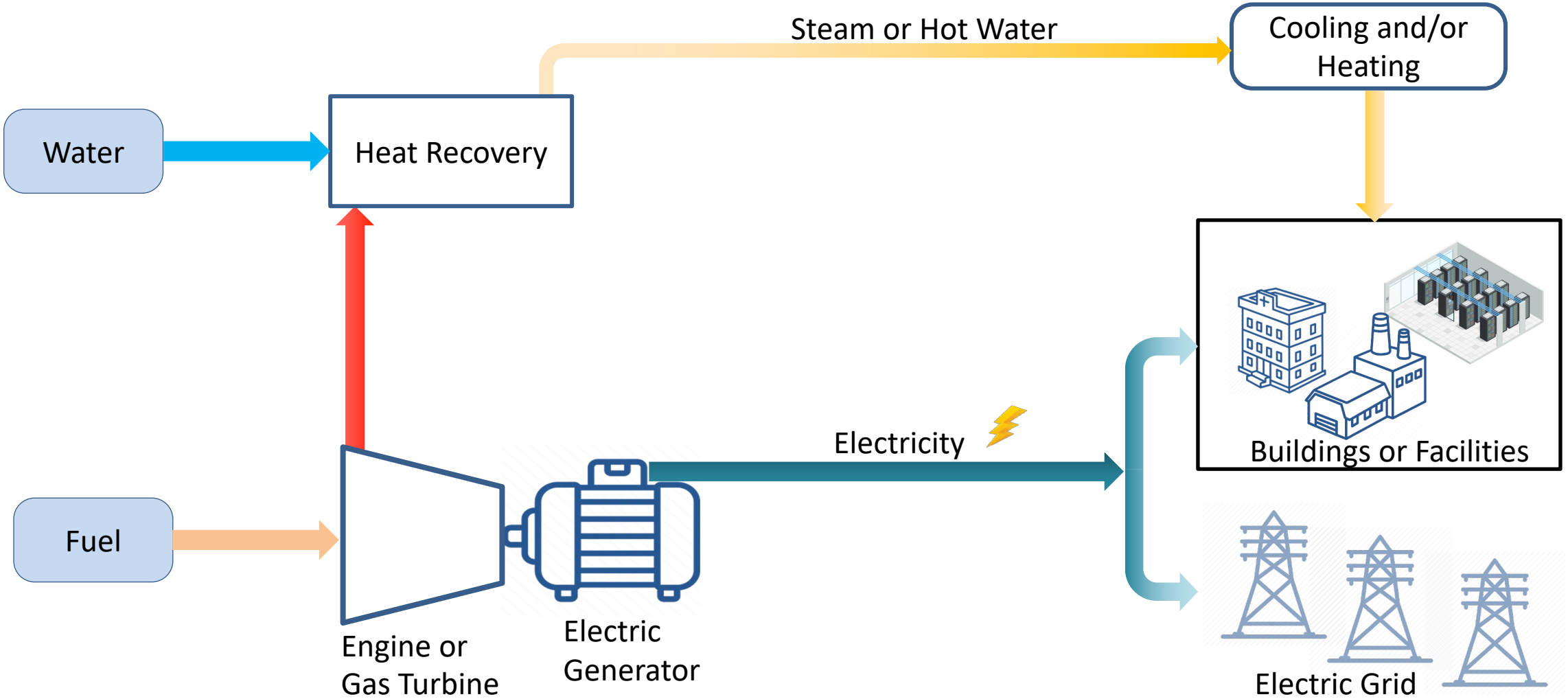
End User Engagement

Stakeholder Engagement

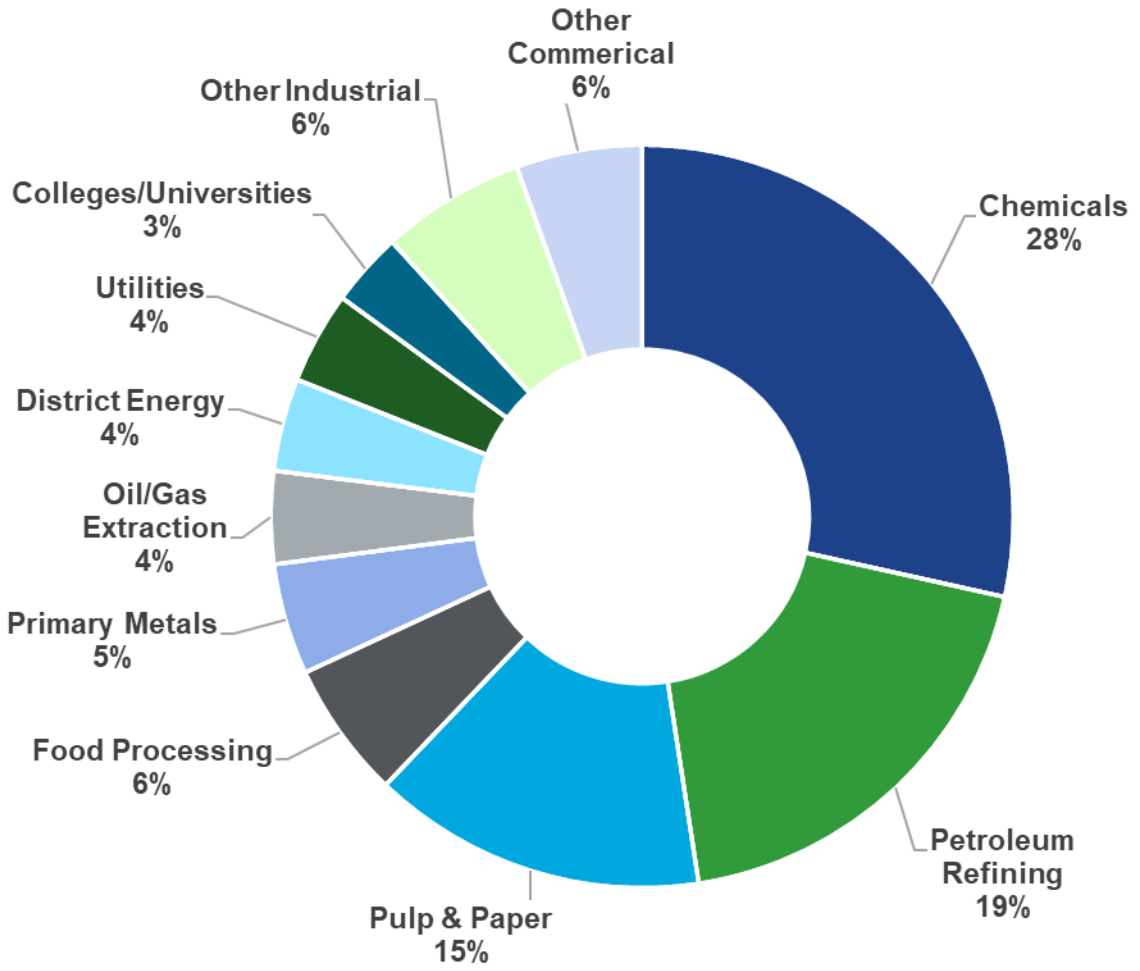
Technical Services

Conventional CHP or Cogen (a.k.a. Topping Cycle)



CHP Today in the United States

Existing CHP Capacity (81.5 GW)



Avoids **1.3 Quadrillion Btus** of fuel consumption annually.

Avoids **218 million tons of CO^2** compared to separate production.

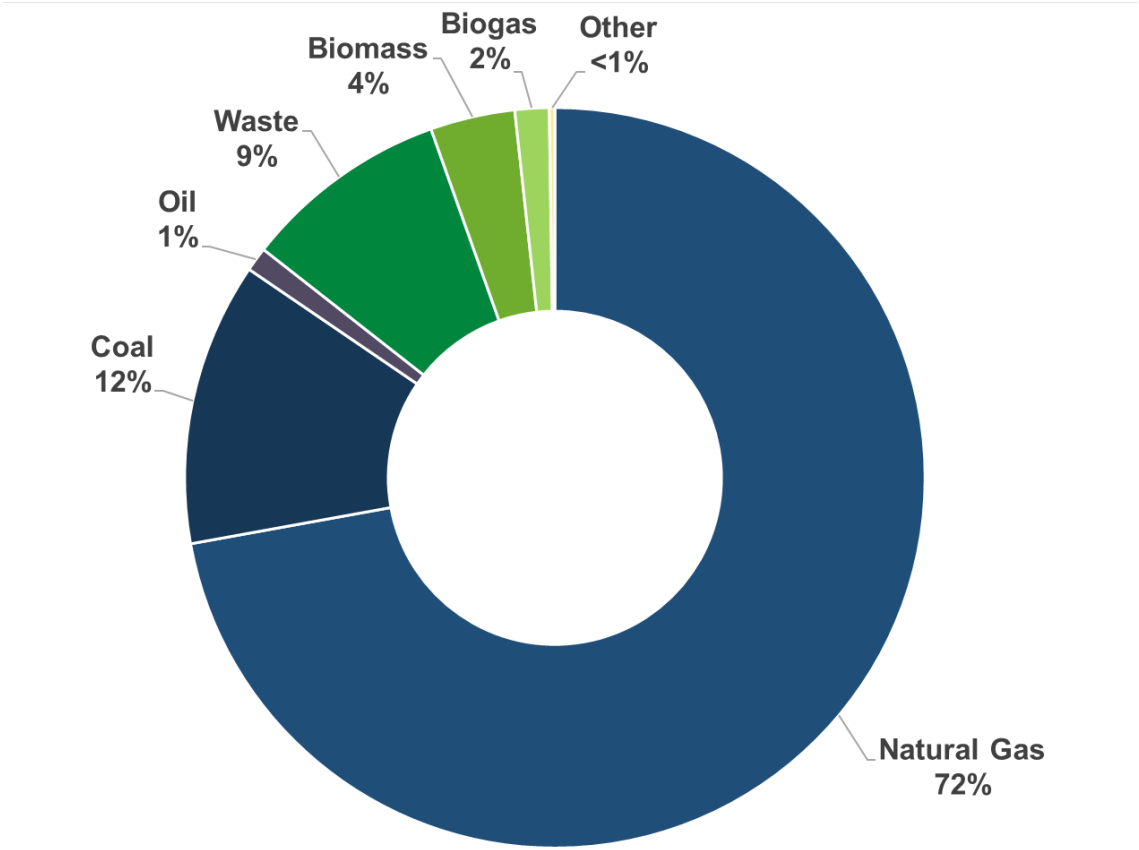
81.5 GW of installed CHP at more than **4,700** industrial and commercial facilities.

7% of U.S. electric generating capacity; 13% of generation.

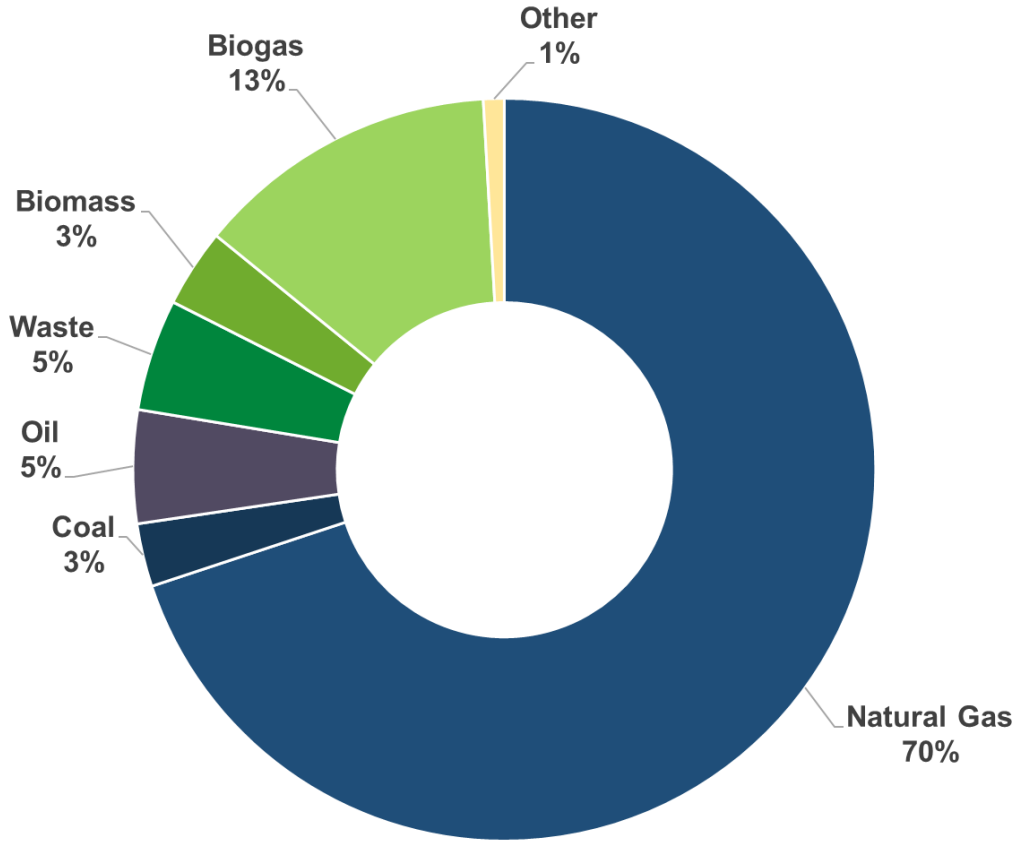
Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

CHP Is Fuel Flexible

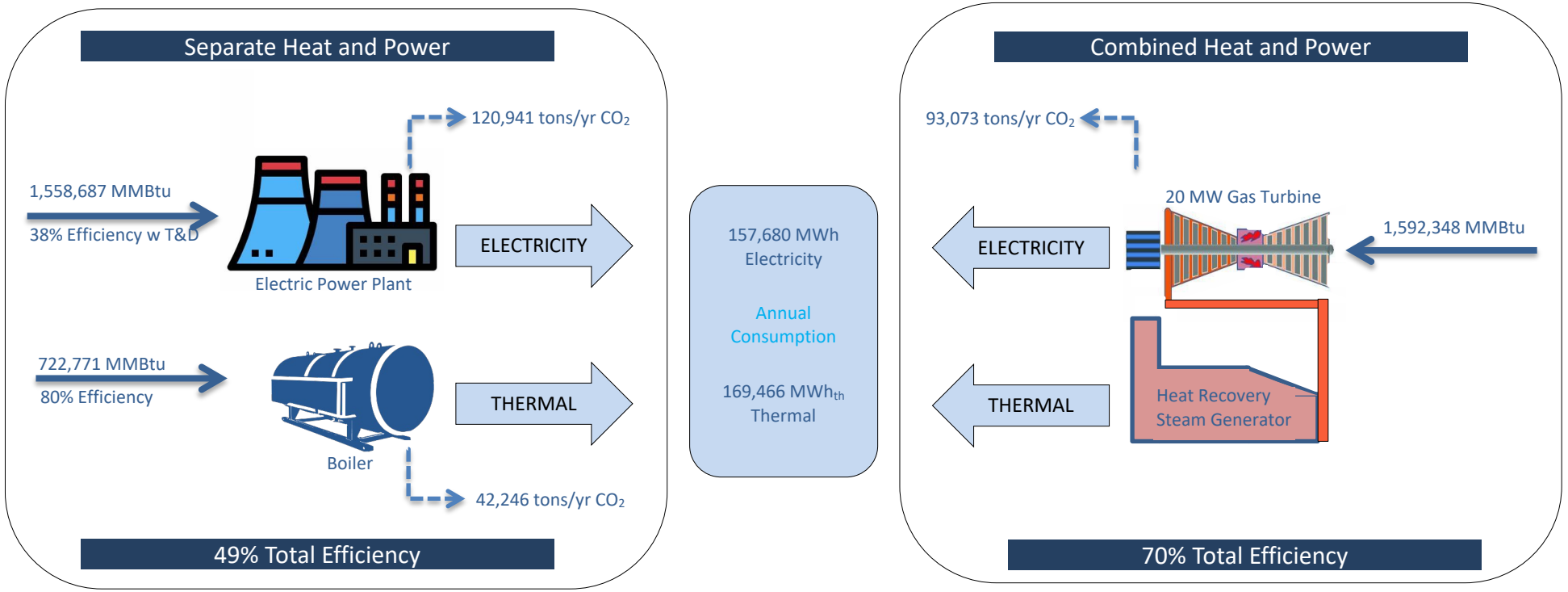
By Capacity – 81.5 GW



By Site – 4,743 Sites



CHP Provides both Energy and CO_2 Emissions Savings



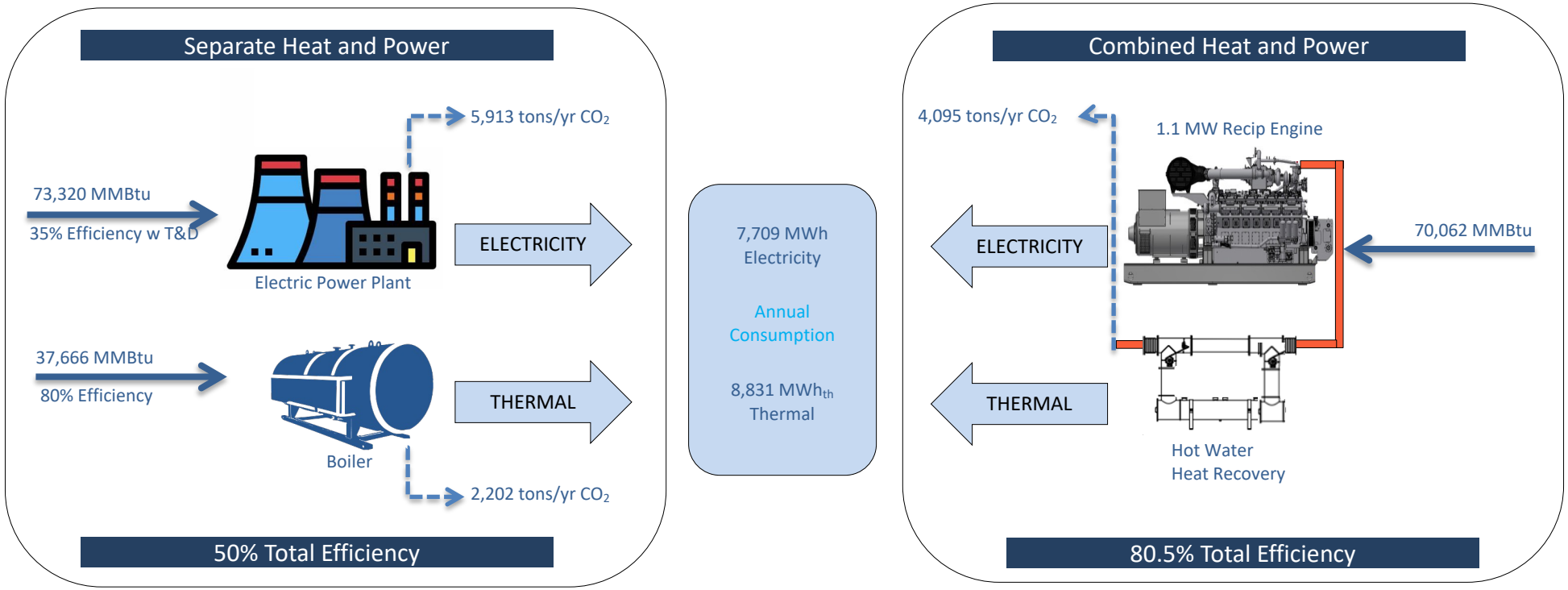
Energy savings: 689,110 MMBtu/yr (727,049 GJ/yr) CO_2 Savings: 70,114 tons/yr (63,606 MT/yr)

20 MW Gas Turbine CHP System

- Natural gas fuel
- 90% load factor (7,884 hours)
- 33.8% electric efficiency
- 75.7 MMBtu/hr steam output
- 100% thermal utilization
- Displaces 80% efficient natural gas boiler
- CO_2 savings based on displacing EPA AVERT Uniform EE grid emissions factor (1,534 lbs CO_2/MWh)

Prepared by Entropy Research, LLC, 11/1/2022

CHP Provides both Energy and CO_2 Emissions Savings



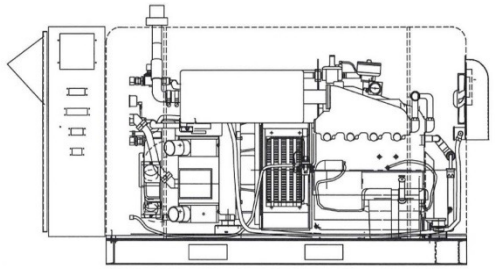
Energy savings: 40,834 MMBtu/yr CO_2 Savings: 4,019 tons/yr

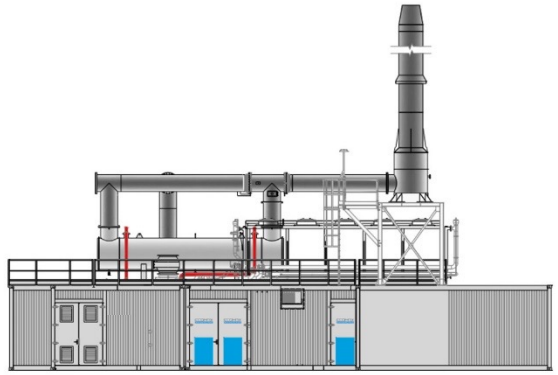
1.1 MW Recip Engine CHP System

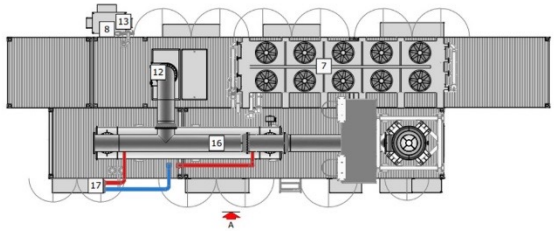
- Natural gas fuel
- 80% load factor (7,008 hours)
- 37.5% electric efficiency
- 4.3 MMBtu/hr hot water output
- 100% thermal utilization
- Displaces 80% efficient natural gas boiler
- CO_2 savings based on displacing EPA AVERT Uniform EE grid emissions factor (1,534 lbs CO2/MWh)

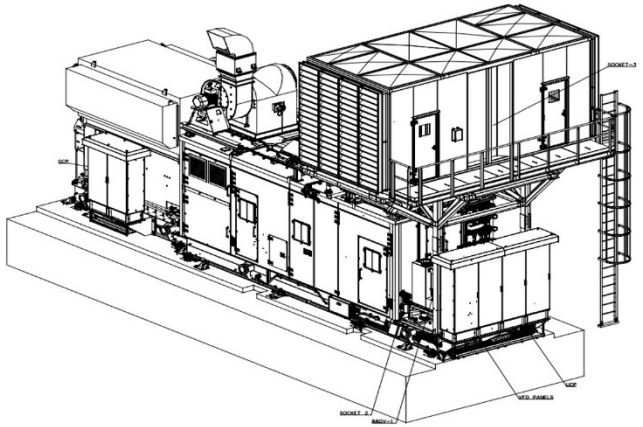
Packaged CHP Systems: Standard Repeatable Designs

- Self Contained Units or Modules
  - Prime Mover
  - Heat Recovery
  - Controls
  - Ancillary Equipment
- Standardized yet customizable
- Factory assembled
- Moveable



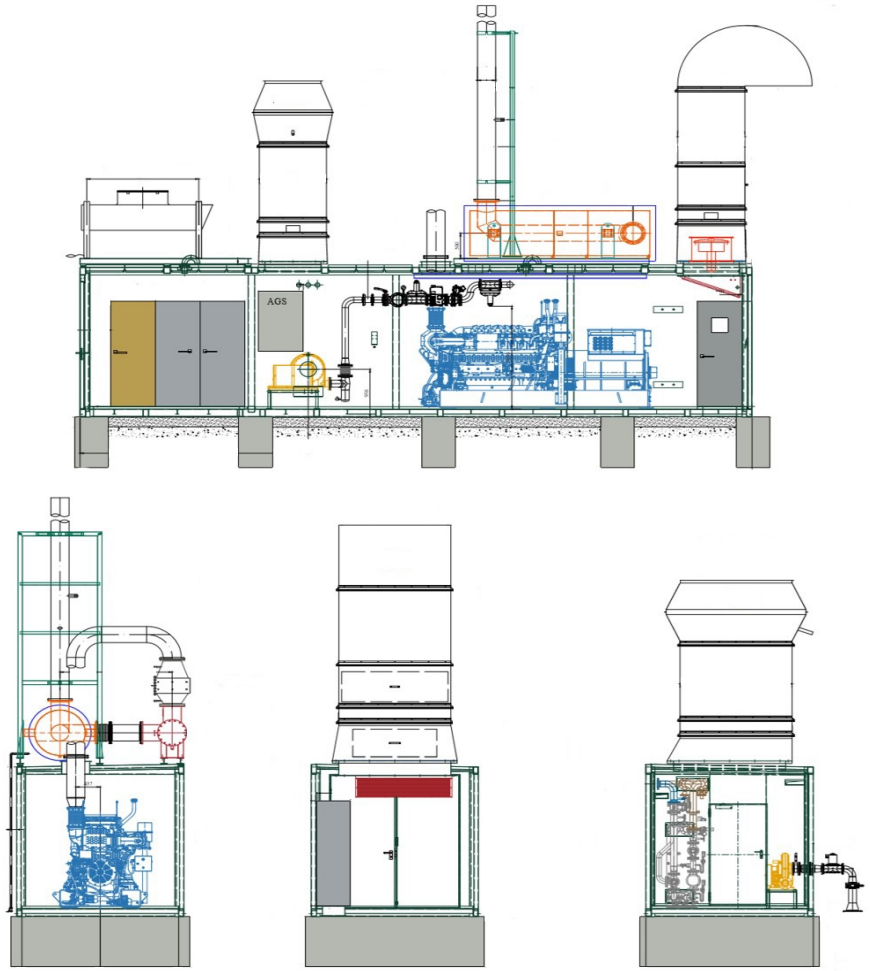






Packaged CHP Systems:

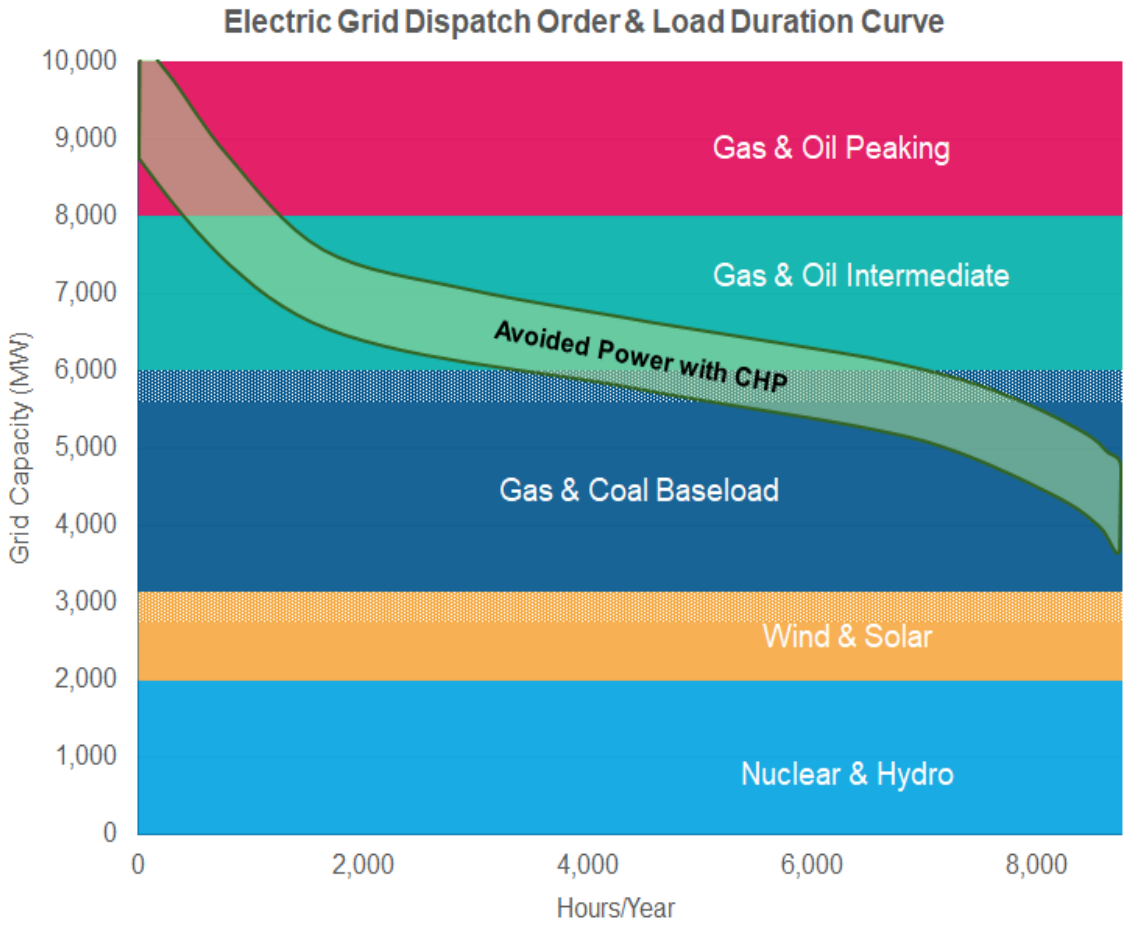
- 100% pre-wired
- 100% pre-piped with customer ready connection
- Properly ventilated
- Sound insulated
- Fire rated
- With a gas detection and smoke alarm
- Fluid containment system
- Auxiliaries sized appropriately and shipped complete with connecting piping and wiring
- Packagers have bulk purchasing power that local contractors do not have



What are Marginal Grid Emissions?

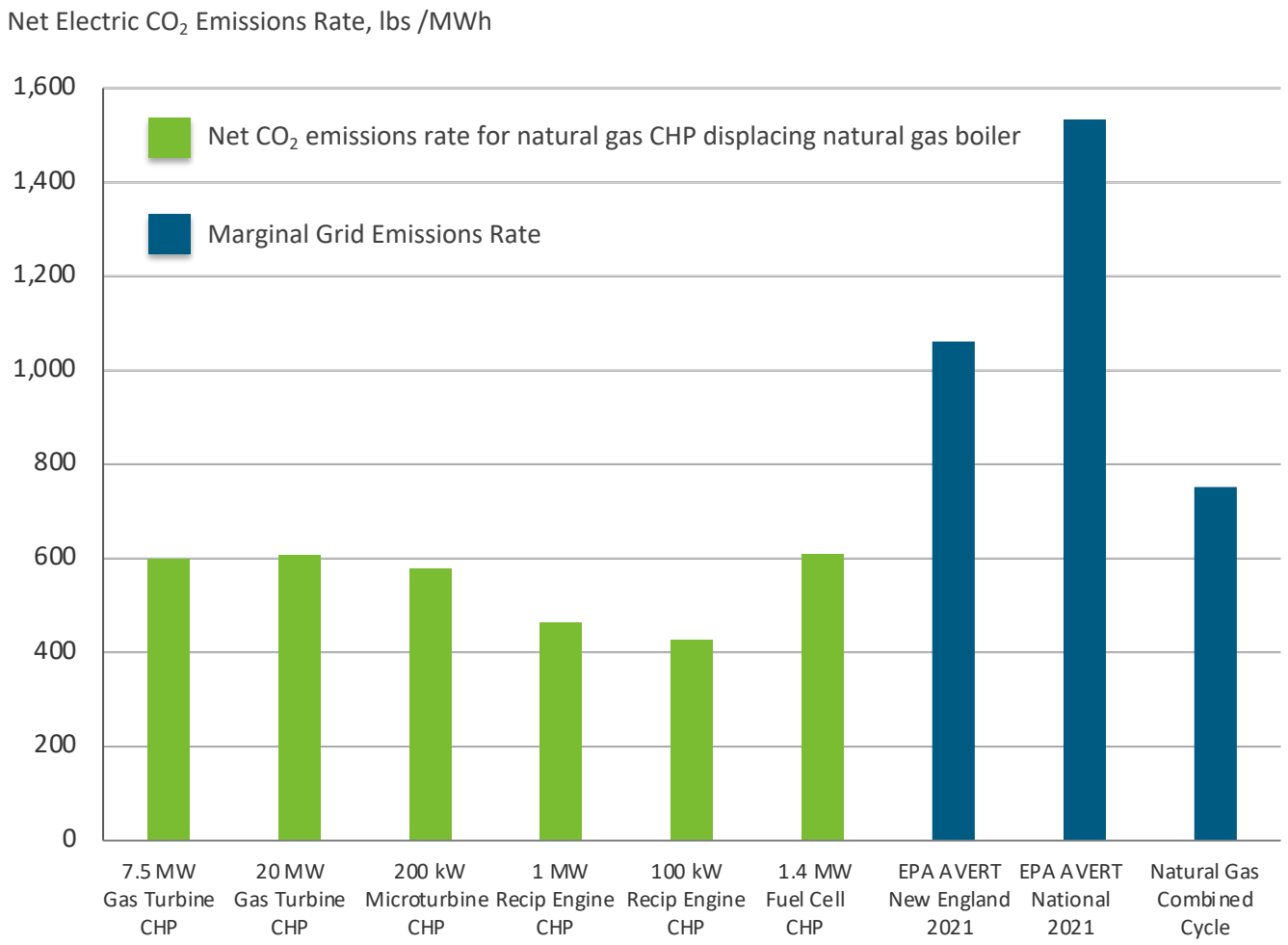
Displaced grid emissions for CHP are based on *marginal grid generation*

- Marginal units are those at the "top of the stack" that set the electricity price in real-time or day-ahead pricing
- Currently, marginal generation tends to be provided by units fueled by gas, oil, and in some cases coal



Natural Gas CHP Emissions vs Marginal Grid Emissions

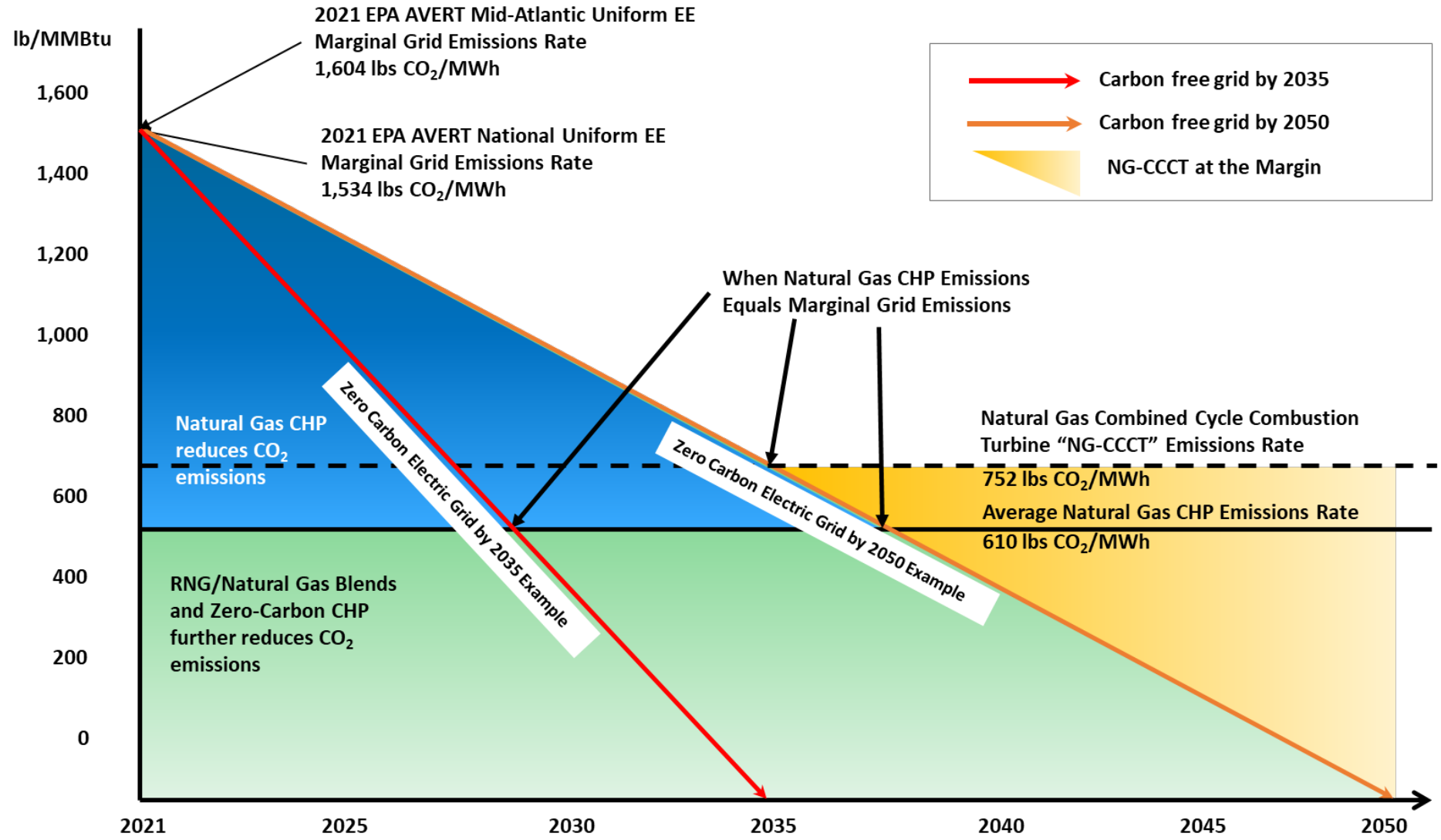
- Natural Gas CHP systems have lower net GHG emissions in terms of lbs CO_2/MWh than current marginal grid generation
- Natural gas CHP displacing natural gas boilers provides emissions savings as long as the marginal grid emissions rate is greater than 430 to 615 lbs CO_2/MWh
- Current marginal grid emissions factors range from 1,071 lbs CO_2/MWh in New England to 1,925 lbs CO_2/MWh in the Rocky Mountain region based on 2021 EPA AVERT data (1,534 national average)
- Emissions factor for state of the art natural gas combined cycle power generation is 750 lbs CO_2/MWh (including T&D losses)



Based on 100% CHP Thermal Utilization

Prepared by: Entropy Research, LLC, 11/1/22

Renewable and Net-Zero Carbon Fuels Maintain CHP's Advantage



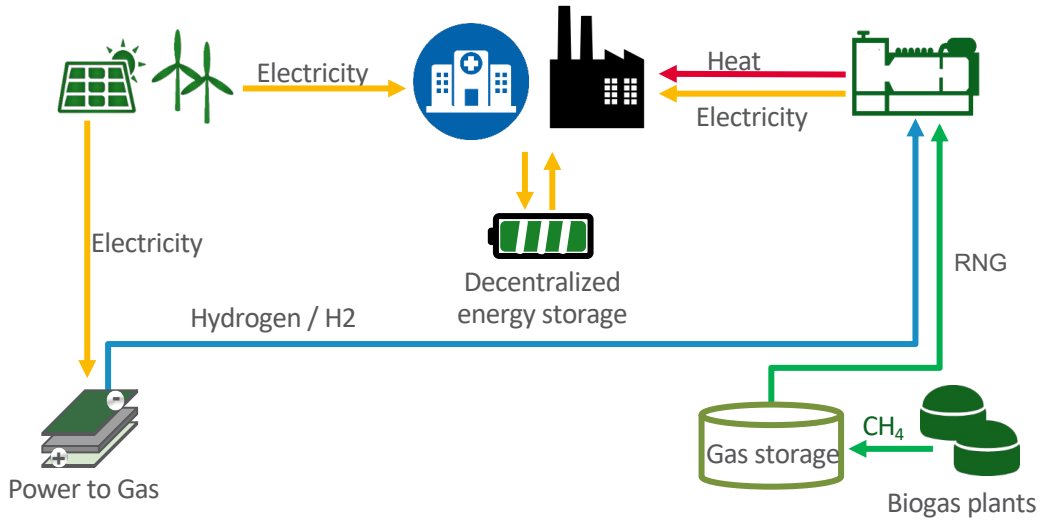
Prepared by Entropy Research, LLC, 7/28/2022

CHP Technical Assistance Partnerships
MID-ATLANTIC

CHP and Decarbonization

- CHP is fuel flexible - CHP currently uses renewable fuels, low carbon waste fuels, and hydrogen where available, and will be ready to use higher levels of biogas, renewable natural gas (RNG) and hydrogen in the future
- CHP is the most efficient way to generate power and thermal energy, and can reduce CO_2 emissions now and in the future
- Net-zero CHP can decarbonize industrial and commercial facilities that are difficult to electrify
- Net-zero CHP can decarbonize critical facilities that need dispatchable on-site power for long duration resilience and operational reliability
- CHP's high efficiency can extend the supply of renewable, low carbon and hydrogen fuels
- CHP can provide dispatchable net-zero generation and regulation support to maintain the long-run resource adequacy of a highly renewable grid

CHP in a Decarbonized Economy



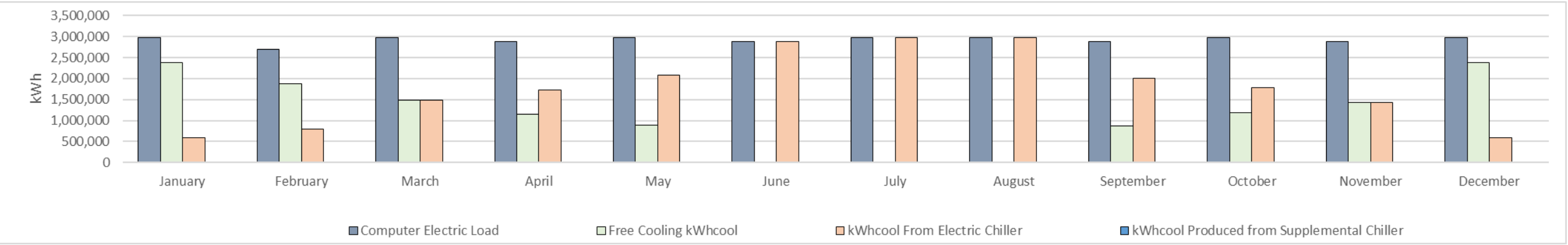
Source: Based on 2G Energy

Simplified Data Center Screening Model

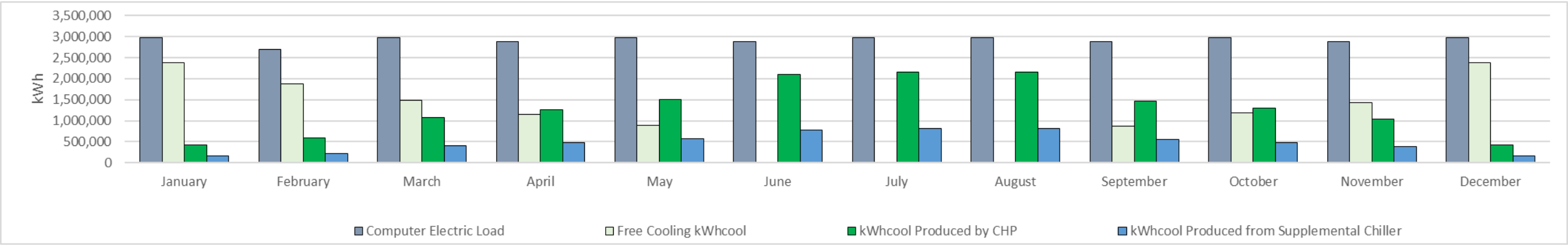
Input Parameters			
Load Following		electric	
Data Center Module Computer Load		4,000	kWh_e
Cooling Load as Percent of Computer Load		100%	
Cooling Load		4,000	kWh_{th}
Cooling Load		1,137	Tons of Cooling
CHP Prime mover Power Capacity		4,241	kWh_e
Electric Grid Delivered Efficiency (EGDE)		35.0%	
Electricity Commodity Price		$0.050	$/kWh
Electricity Capacity Price		$0.035	$/kWh
All-in Average Electricity Price		$0.085	$/kWh
Thermal Load Following Electric Chiller Efficiency (electric load following small supplemental electric chiller efficiency calculated separately)		0.55	kWe/ton
All in Natural gas price		$6.00	MMBtu
CHP Prime Mover Efficiency		40.8%	HHV
Absorption chiller COP		0.70	
CHP Maintenance Cost		$0.025	$/kWh
Standby Charges % of CHP Power Gen 10% Thermal and 0% Electric Following		0%	
Output Data			
BAU Site Energy Simple Computer and Cooling PUE		1.16	PUE simple
BAU Primary Energy Simple Computer and Cooling PUE		1.16	PUE simple
CHP Site Energy Savings		-137%	
CHP Primary energy Savings		8%	Based on EGDE
CHP Site Energy Simple Computer and Cooling PUE		2.74	PUE simple
CHP Primary Energy Simple Computer and Cooling PUE		0.96	PUE simple
BAU Electric Grid Emissions Factor	Non-baseload	1,410	lb/MWhr
BAU Electric Grid Emissions Annual Emissions		28,566	tons CO_2/year
Percent Hydrogen Blended on Energy Basis		0%	
CHP Fuel CO_2 Emissions		19,167	tons CO_2/year
Electric Grid Emissions with CHP		0	tons CO_2/year
Total CHP plus Supplemental Grid Emissions		19,167	tons CO_2/year
CO_2 Reduction with CHP		9,399	tons CO_2/year
Operating Savings with CHP		$547,825	

4 MW CHP Power and Cooling Modeled Example

BAU Electric Grid Cooling plus Free cooling (kW_e and kW_{th})



CHP Electric Generation & Absorption Cooling plus Free cooling (kW_e and kW_{th})



4 MW CHP Power and Cooling Modeled Example

Output Data			
BAU Site Energy Simple Computer and Cooling PUE		1.10	PUE simple
BAU Primary Energy Simple Computer and Cooling PUE		1.10	PUE simple
CHP Site Energy Savings		-140%	
CHP Primary energy Savings		7%	Based @ 35% HHV
CHP Site Energy Simple Computer and Cooling PUE		2.63	PUE simple
CHP Primary Energy Simple Computer and Cooling PUE		0.92	PUE simple
BAU Electric Grid Emissions Factor	Non-baseload U.S.	1,410	lb/MWhr
BAU Electric Grid Emissions Annual Emissions		27,059	tons CO_2/year
Percent Hydrogen Blended on Energy Basis		0%	
CHP Fuel CO_2 Emissions		18,364	tons CO_2/year
Electric Grid Emissions with CHP		0	tons CO_2/year
Total CHP plus Supplemental Grid Emissions		18,364	tons CO_2/year
CO_2 Reduction with CHP		8,695	tons CO_2/year

4 MW CHP Power and Cooling Modeled Example

Annual 4 MW CHP Operating Savings vs Separate Heat and Power Screening

		Electricity $/kWh (all-in)		
		$0.09	$0.10	$0.11
Natural Gas $/MMBtu	$8.50	-$316,249	-$2,071	$312,107
	$7.50	$67,569	$695,925	$695,925
	$6.50	$451,388	$765,566	$1,079,744

4 MW CHP Power and Cooling Modeled Example

Fuel Decarbonization

	100% NG	20% H2 by volume	20% RNG by volume
CHP CO_2 Savings vs BAU	8,695	9,797	12,368

Inflation Reduction Act

The increase in the Investment Tax Credit for CHP in the 2022 Inflation Reduction Act from 6% to 30% (40% for domestic manufacturers) and perhaps up to 50% in some cases, for all projects started before January 1, 2025, and for net-zero emissions projects after that date may impact the energy economics of these systems.

MCA CHP TAP Educational Webinar: New CHP Tax Incentives in the Inflation Reduction Act

https://register.gotowebinar.com/recording/8658387316124991833

THANKS FOR LISTENING

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COMBINED HEAT AND POWER ALLIANCE

Webinar

Combined Heat and Power: A Solution for Data Center Energy Needs

Tom Parker
Burns & McDonnell

Phil Reid
RED Engineering (ENGIE)

Pete Spicher
PSECU

Pennsylvania State Employees Credit Union (PSECU) – Harrisburg, PA

- C800 MicroTurbine
- 800 kW of Electricity operating in Grid Connect
- Hot Water & Chilled Water Produced
- Backup power & cooling to data center in grid failure

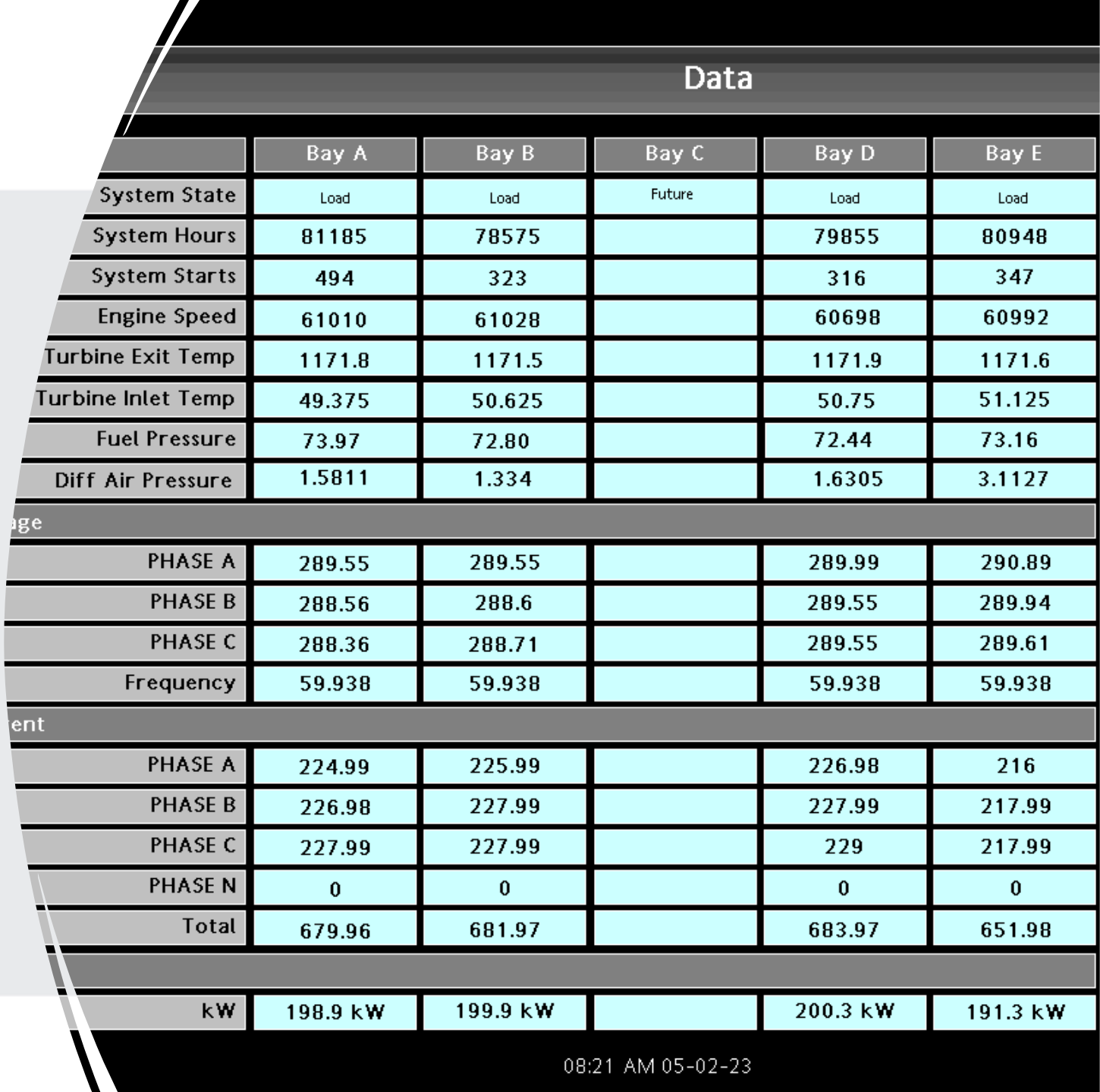
Benefits:

- Payback is exceeding the original model
- System helped client achieve LEED Gold status in 2014
- Has provided backup power to site multiple times since installation

Capstone Green Energy

PSECU – Harrisburg, PA

- System Commissioned April 2014
- 80,000 System Hours
- Demonstrates Reliable Uninterrupted Service for 9+ Yrs.



Data

	Bay A	Bay B	Bay C	Bay D	Bay E
System State	Load	Load	Future	Load	Load
System Hours	81185	78575		79855	80948
System Starts	494	323		316	347
Engine Speed	61010	61028		60698	60992
Turbine Exit Temp	1171.8	1171.5		1171.9	1171.6
Turbine Inlet Temp	49.375	50.625		50.75	51.125
Fuel Pressure	73.97	72.80		72.44	73.16
Diff Air Pressure	1.5811	1.334		1.6305	3.1127
age					
PHASE A	289.55	289.55		289.99	290.89
PHASE B	288.56	288.6		289.55	289.94
PHASE C	288.36	288.71		289.55	289.61
Frequency	59.938	59.938		59.938	59.938
ent					
PHASE A	224.99	225.99		226.98	216
PHASE B	226.98	227.99		227.99	217.99
PHASE C	227.99	227.99		229	217.99
PHASE N	0	0		0	0
Total	679.96	681.97		683.97	651.98
kW	198.9 kW	199.9 kW		200.3 kW	191.3 kW

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Capstone Green Energy

Middle East Data Center
High-Availability Power and Cooling

Water-Wise Reliability and Resilience in the Desert

Plans for a new 60MW data center in the Middle East were hampered by an electric grid that was both unreliable and under capacity for the project. Data center developers sought not only alternative solutions for off-the-grid power and cooling, but also a path to a sustainable zero-carbon facility.

Solution

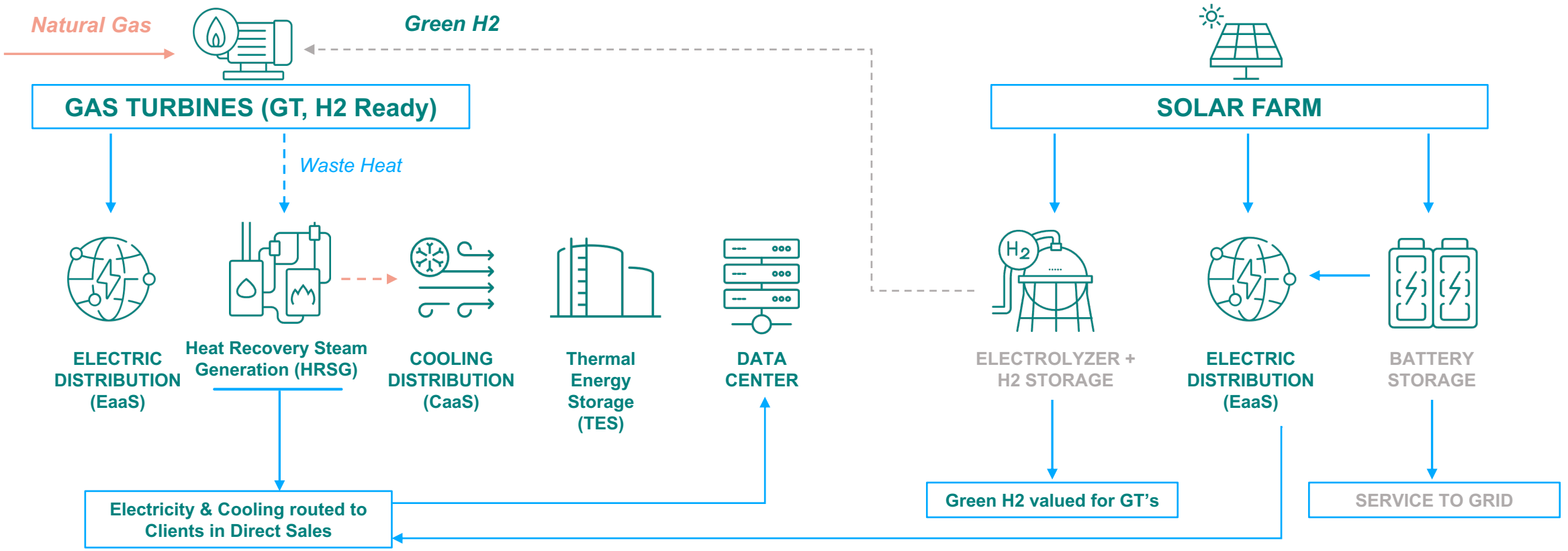
ENGIE and RED (an ENGIE company) designed a high-availability microgrid to provide combined power and cooling to the data center.

- Initial gas turbine supply to be replaced with green hydrogen.
- Solar farm to power H2 electrolysis and turbines, with backup to battery storage.
- Solution includes water storage, recycling, and treatment, with connection to municipal water system.
- ENGIE and RED will build, own, and operate the integrated facility under a long-term concession.

Projected Benefits

- 24% improvement in power usage effectiveness (PUE)
- 48% lower power consumption
- Reduced CapEx and OpEx (including reduced staffing needs)
- Guaranteed roadmap to carbon neutrality
- Marginal use of water
- Smaller data center footprint

Energy Center Components



Infrastructure, Feasibility & Timing

Webinar

Combined Heat and Power: A Solution for Data Center Energy Needs

COMBINED HEAT AND POWER ALLIANCE

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Columbia Gas

David Lewis
Washington Gas

Buddy Rizer
Loudoun, Va. Economic Development

Charles Miller
Washington Gas

Combined Heat and Power Alliance

A Solution for Data Center Energy Needs

May 11, 2023

AltaGas | WGL | SEMCOENERGY

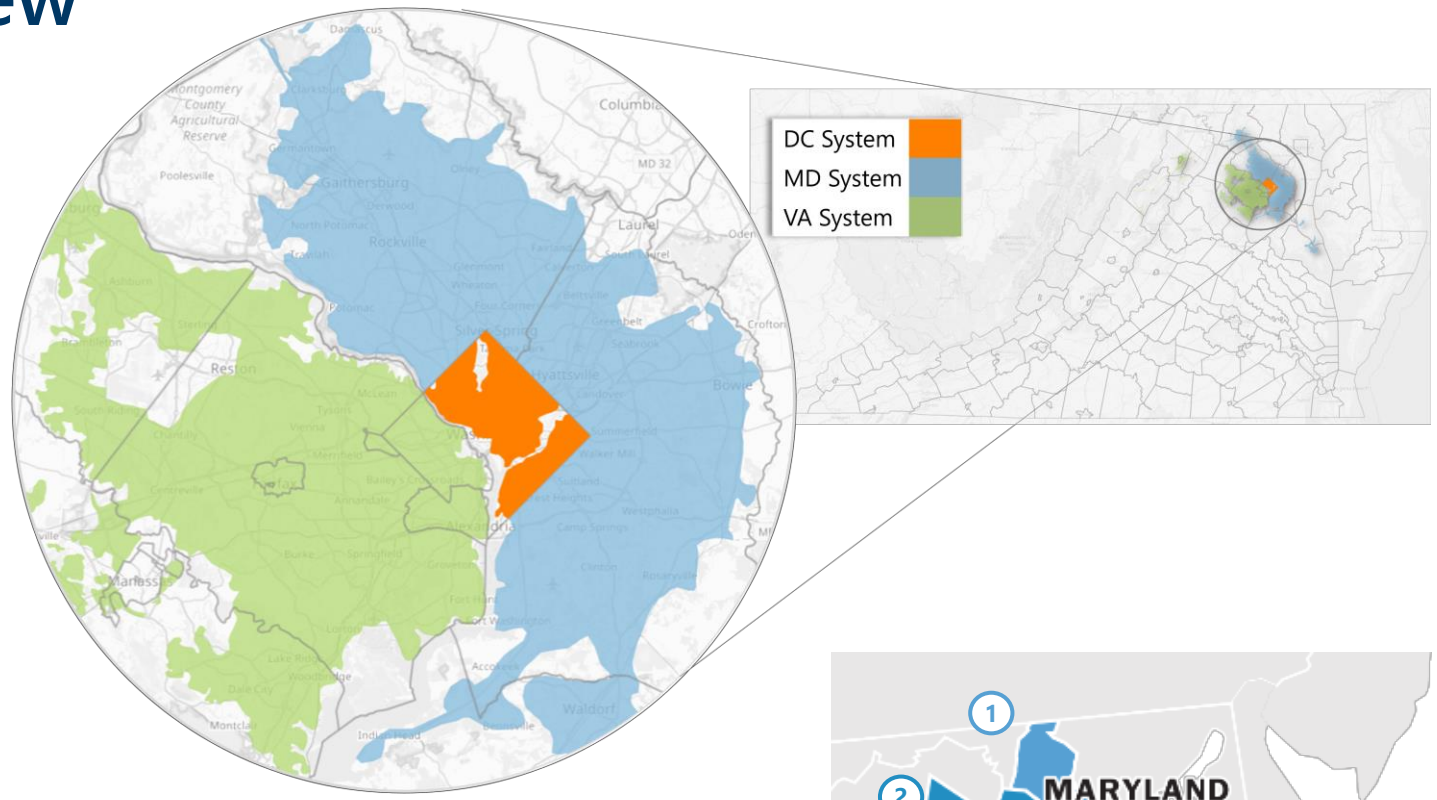
Washington Gas Overview

Overview

- A wholly owned subsidiary of AltaGas Ltd, Washington Gas is a regulated natural gas utility that provides safe, reliable natural gas service to more than 1.2 million customers in the District of Columbia, Maryland and Virginia
- The company has been providing energy to residential, commercial and industrial customers for 175 years

Strategic Priorities

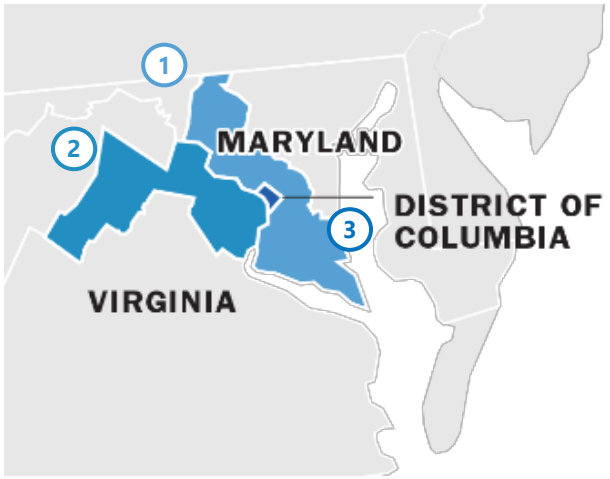
- Operate a safe and reliable system to deliver critical energy to customers
- Invest to modernize our network
- Continue operational excellence improvements
- Position the asset base for the fuels of the future



1 ~512,000 customers

2 ~550,000 customers

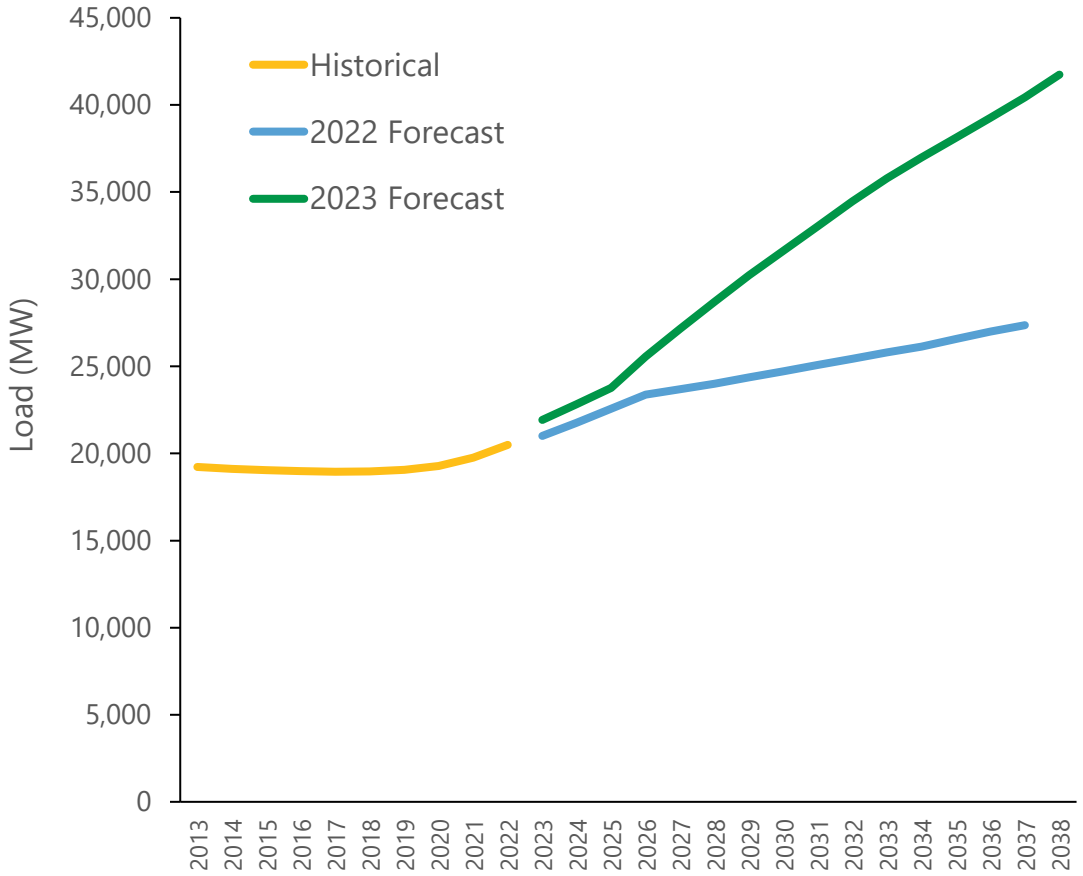
3 ~165,000 customers



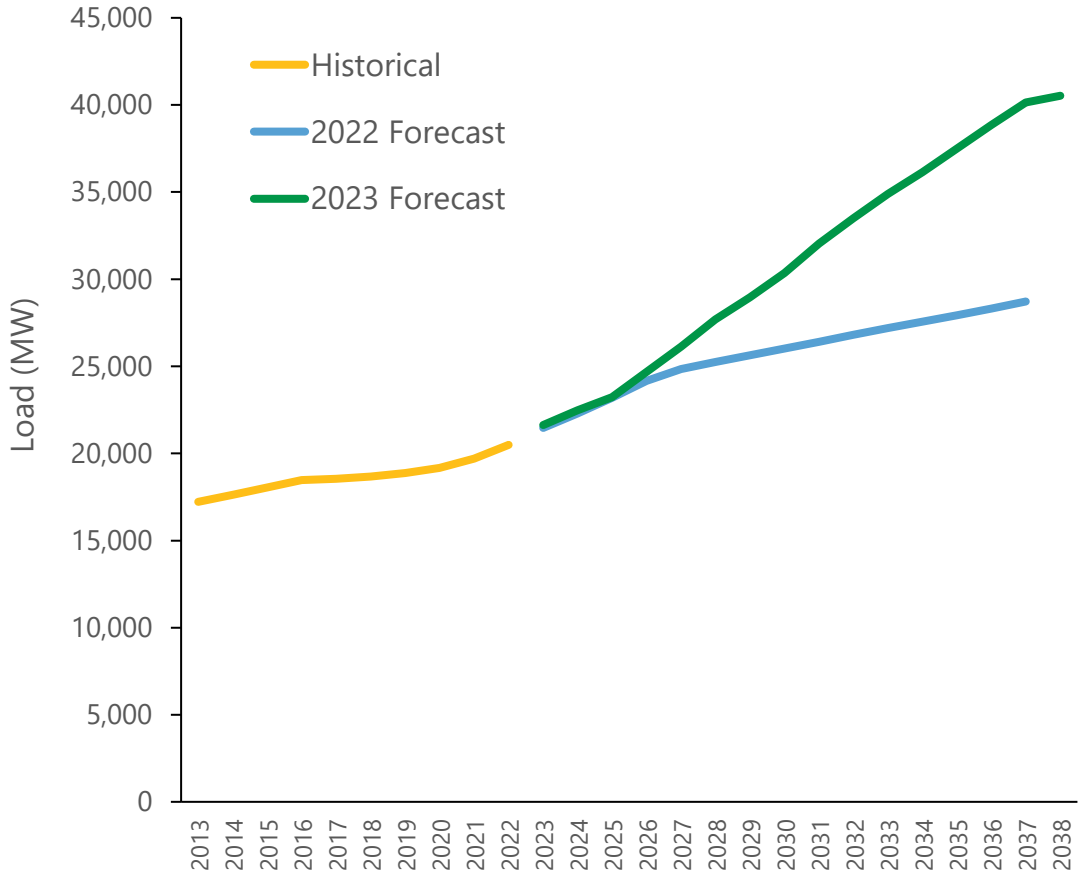
Dominion VA Load Forecasts

PJM Forecast 2022 vs 2023 (1)

Summer Peak



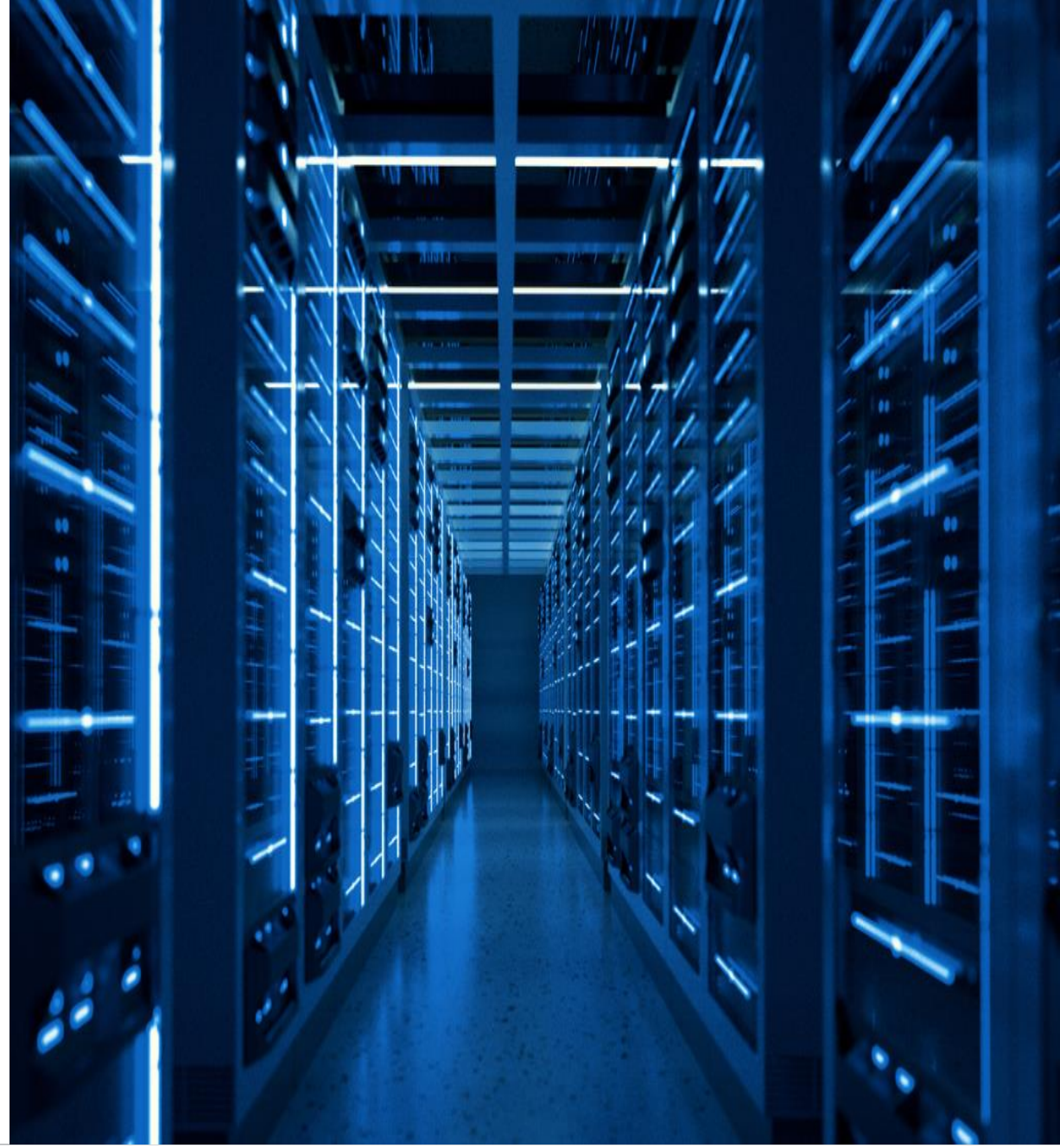
Winter Peak



1) Source: PJM Load Forecast Report 2023

WGL System Information

- Location, location, location
- Weather driven seasonality
- Reliability and resiliency
- Decarbonization objectives



WGL System Information

- Supply options
  - Distribution – can only support up to half a typical data center at most, depending on location
  - Transmission – can support much greater demand, ideal supply for data centers
- Delivery pressures
  - Distribution – can only accommodate up to 15 psig delivery pressure as a maximum, depending on location
  - Transmission – targets 80 psig delivery pressure 'as a floor' with typical operating pressures 150 – 325 psig
- Volumes
  - Some regions have opportunities to increase capacity in the short-term (less than 2 years)
- Demand scaling
  - Location dependent option to begin natural gas service of a smaller MW demand on distribution as transmission infrastructure is designed and installed to the site for final MW demand
- Commodity Supply
  - WGL standard recommendation is to seek third-party supply in the market

Data Center Market Survey (Request for Information)

- Expect to launch Market Survey Request for Information (RFI) at end of May
- All CHPA Webinar Attendees will receive email with the link to Market Survey RFI to obtain key information:
  - Location and stage of development
  - Pressure requirements
  - Load requirements, etc.
- Washington Gas will work with Engineering Firms to analyze and optimize system upgrades and requirements
- Notify Data Centers of cost and feasibility options

QUESTIONS?

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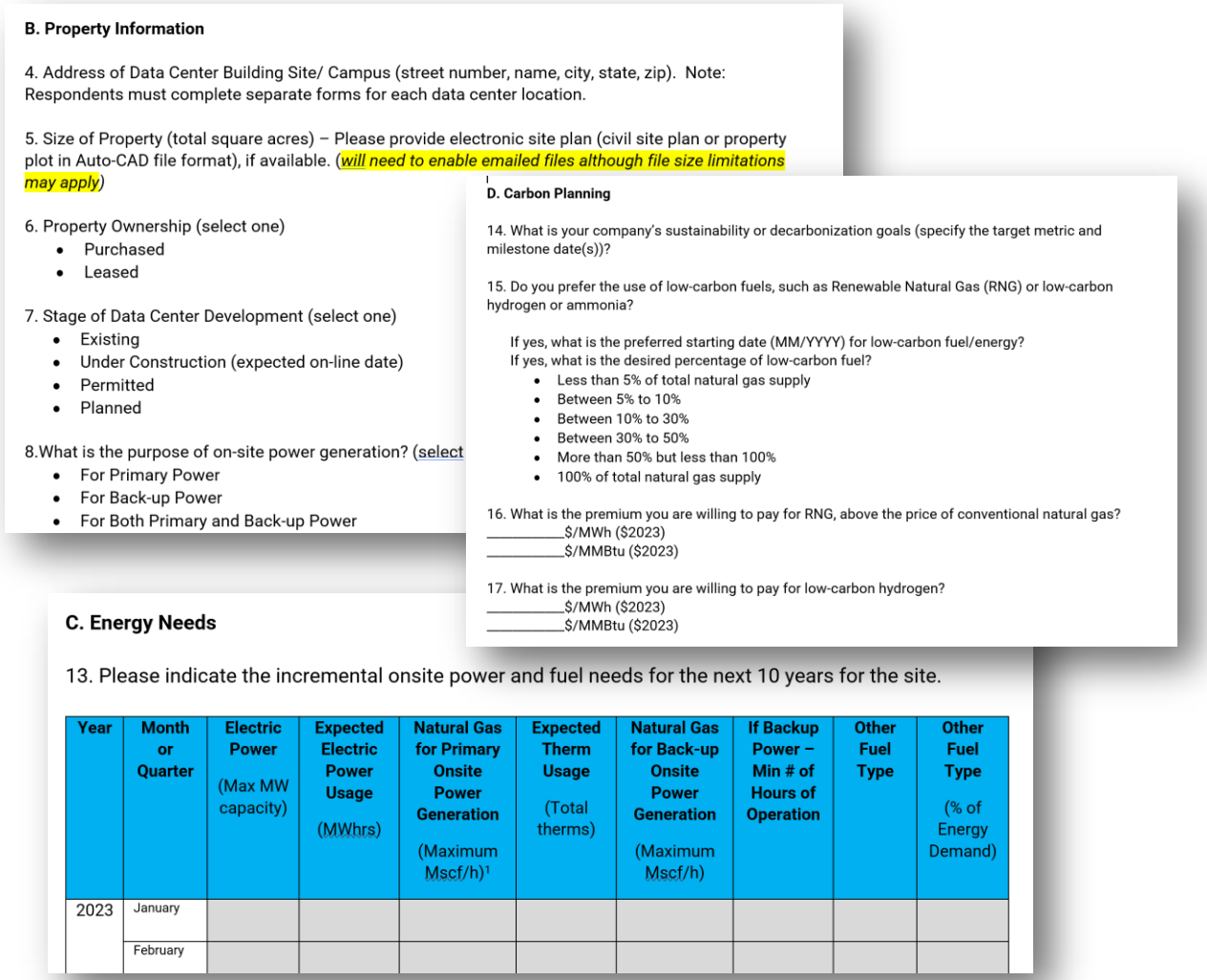

B. Property Information

4. Address of Data Center Building Site/ Campus (street number, name, city, state, zip). Note: Respondents must complete separate forms for each data center location.

5. Size of Property (total square acres) – Please provide electronic site plan (civil site plan or property plot in Auto-CAD file format), if available. (*will need to enable emailed files although file size limitations may apply*)

6. Property Ownership (select one)
- Purchased
- Leased

7. Stage of Data Center Development (select one)
- Existing
- Under Construction (expected on-line date)
- Permitted
- Planned

8.What is the purpose of on-site power generation? (select
- For Primary Power
- For Back-up Power
- For Both Primary and Back-up Power

D. Carbon Planning

14. What is your company's sustainability or decarbonization goals (specify the target metric and milestone date(s))?

15. Do you prefer the use of low-carbon fuels, such as Renewable Natural Gas (RNG) or low-carbon hydrogen or ammonia?

If yes, what is the preferred starting date (MM/YYYY) for low-carbon fuel/energy?
If yes, what is the desired percentage of low-carbon fuel?
- Less than 5% of total natural gas supply
- Between 5% to 10%
- Between 10% to 30%
- Between 30% to 50%
- More than 50% but less than 100%
- 100% of total natural gas supply

16. What is the premium you are willing to pay for RNG, above the price of conventional natural gas?
_____$/MWh ($2023)
_____$/MMBtu ($2023)

17. What is the premium you are willing to pay for low-carbon hydrogen?
_____$/MWh ($2023)
_____$/MMBtu ($2023)

C. Energy Needs

13. Please indicate the incremental onsite power and fuel needs for the next 10 years for the site.

Year	Month or Quarter	Electric Power (Max MW capacity)	Expected Electric Power Usage (MWhrs)	Natural Gas for Primary Onsite Power Generation (Maximum Mscf/h)[1]	Expected Therm Usage (Total therms)	Natural Gas for Back-up Onsite Power Generation (Maximum Mscf/h)	If Backup Power – Min # of Hours of Operation	Other Fuel Type	Other Fuel Type (% of Energy Demand)
2023	January								
	February								

Information

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Q&A Discussion

Thank You!

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