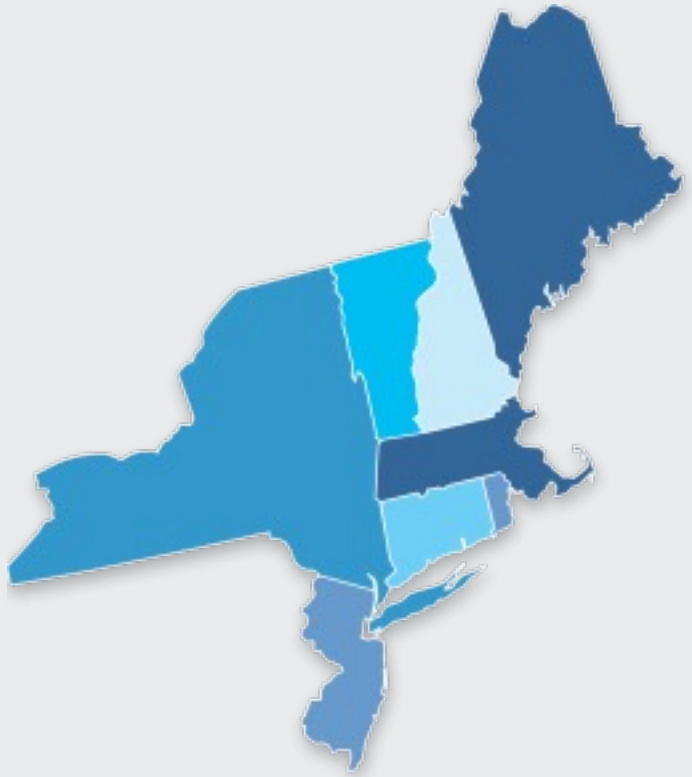
NE CHAPTER
OF THE COMBINED HEAT AND POWER ALLIANCE

Webinar: Carbon Capture and CHP Technology

Thursday, June 15, 2023

Who We Are

- A coalition of manufacturers, system developers, engineering firms, and end-user representatives promoting an economic and regulatory environment that accelerates deployment of CHP systems in the Northeast that are highly efficient, provide economic, environmental, and reliability benefits, and enhance resiliency.



2023 Policy Actions

- Completed:
  - **Massachusetts** – Met with MA Undersecretary of Energy; follow up with MA Dept. of Environmental Protection staff
  - **New Jersey** – BPU filing for continued funding of CHP program
  - **New York** – PSC filing for inclusion of CHP in standby rate exemptions

2023 Policy Actions

- To be completed:
  - **Massachusetts** – Comments on Clean Heat Standard
  - **Massachusetts** – Meeting with Commissioner Jamie Van Nostrand
  - **New Jersey** – BPU filing for support of CHP in ESIP
  - **New York** – PSC order initiating process regarding the Zero Emissions Target in the Clean Energy Standard
  - **New York** – Meeting with Commissioner Diane Burman
  - **Rhode Island** – Comments for CHP incentive program renewal

Webinar

NE CHAPTER
OF THE COMBINED HEAT AND POWER ALLIANCE

The NE Chapter of the CHP Alliance Presents:

Carbon Capture and CHP Technology

THURSDAY, JUNE 15 **1:00 - 2:00 PM ET**

Brian Asparro
Carbon Quest

Meegan Kelly
Industrial Efficiency & Decarbonization Office, U.S. DOE

Vishnu Barran
Clarke Energy

Johnathan Coleman
NE Chapter, Solar Turbines

U.S. DEPARTMENT OF ENERGY

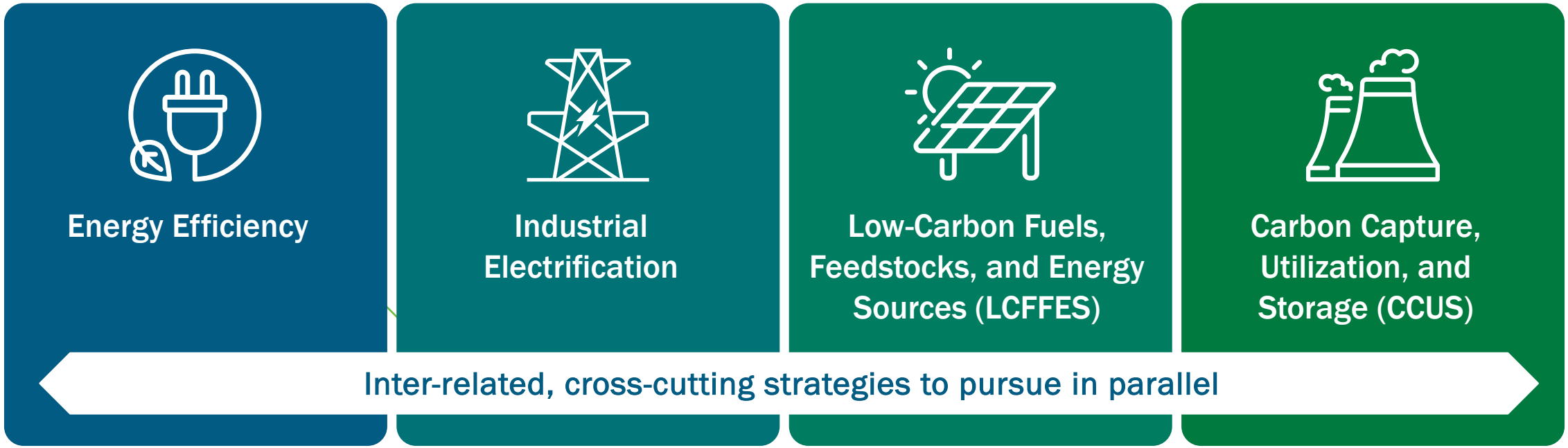
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

CHP and Decarbonization

Meegan Kelly, Technology Manager
Industrial Efficiency and Decarbonization Office
June 14, 2023

DOE Industrial Decarbonization Roadmap

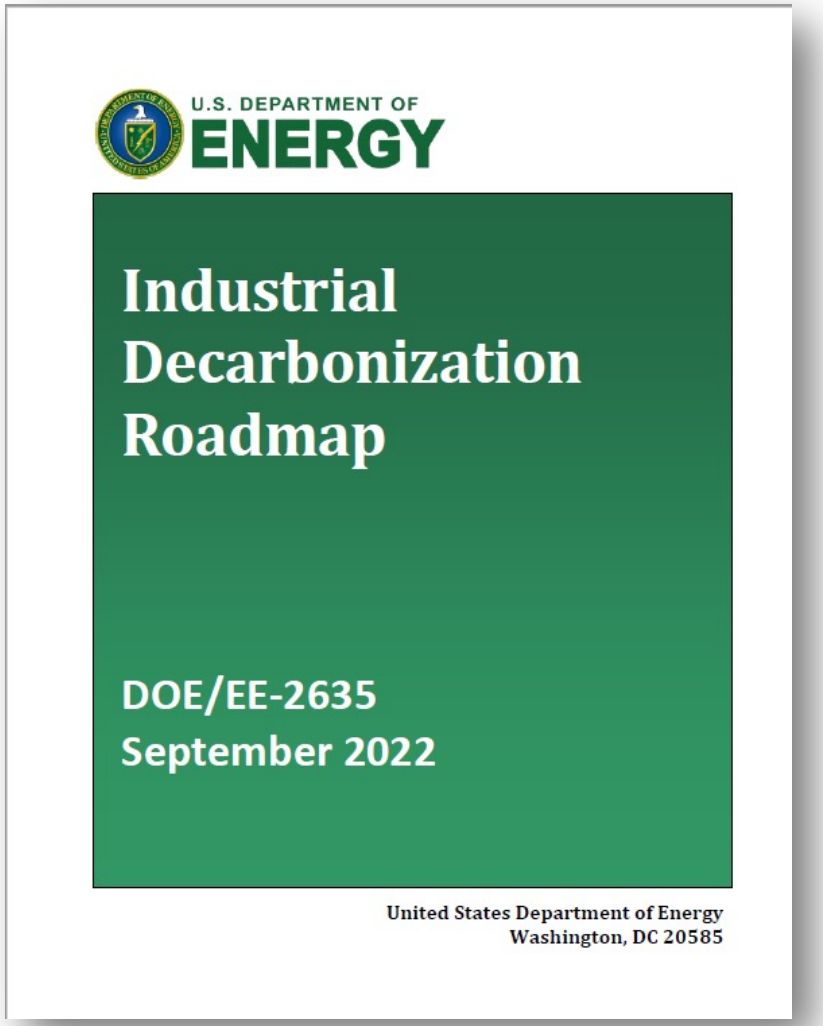
Four Main Strategies to Decarbonize the Manufacturing Sector



https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap

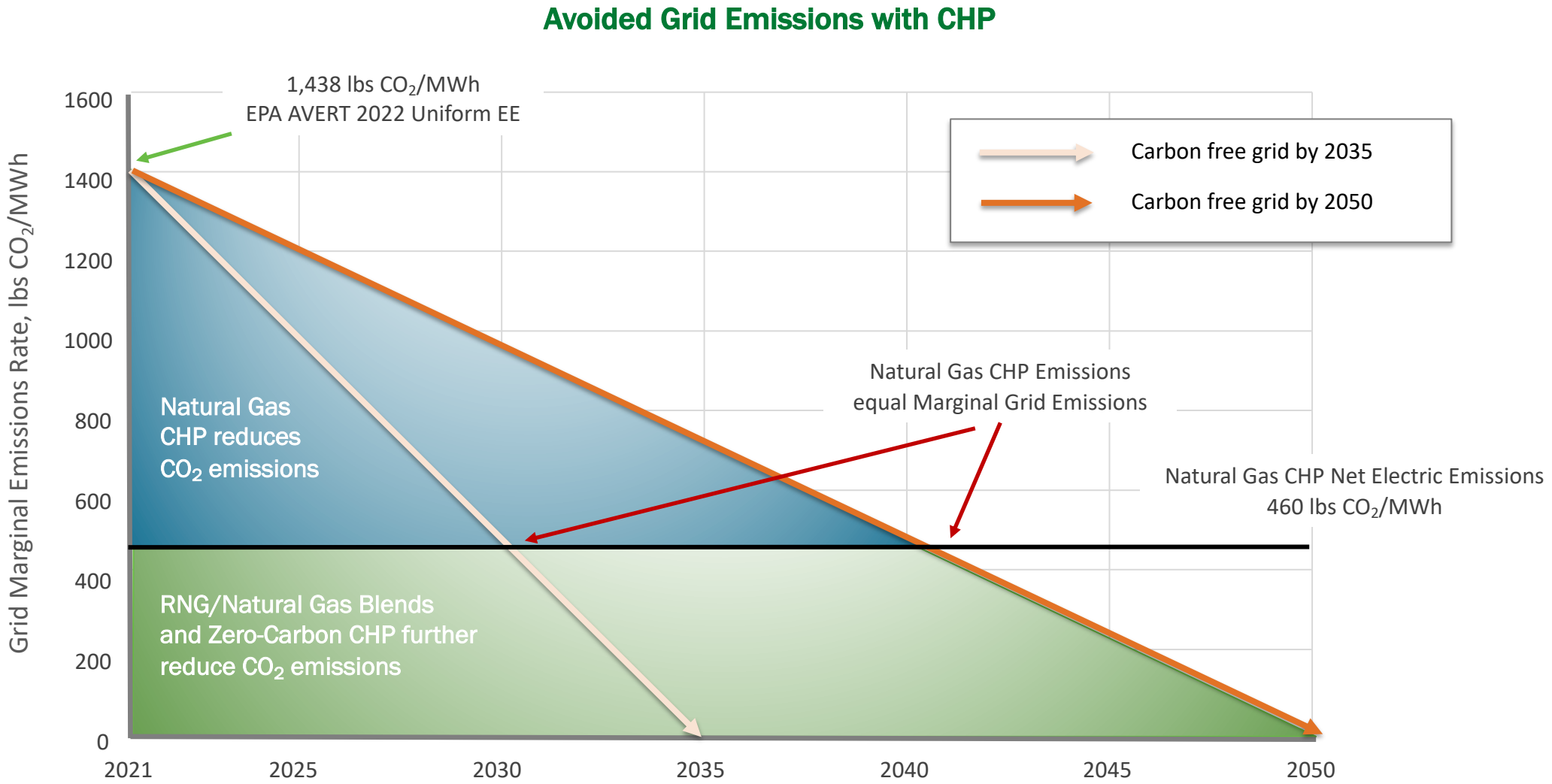
CHP in Industrial Decarbonization Roadmap

- **Industrial CHP can provide significant GHG emissions reductions in the near- to mid-term** as marginal grid emissions continue to be based on a mix of fossil fuels in most areas of the country.
- In order to prevent lock-in, **CHP units installed today must have emissions below marginal grid emissions** for the duration of their useful lifetime, including through retrofits to use clean sources of energy where possible.
- **RNG and hydrogen fueled CHP systems can be a long-term path** to decarbonizing industrial thermal processes resistant to electrification because of technology or cost barriers, and for critical operations where dispatchable onsite power is needed for resilience and reliability.



https://www.energy.gov/sites/default/files/2022-09/Industrial Decarbonization Roadmap.pdf

Transitioning to Renewable Fuels and Net-Zero Strategies

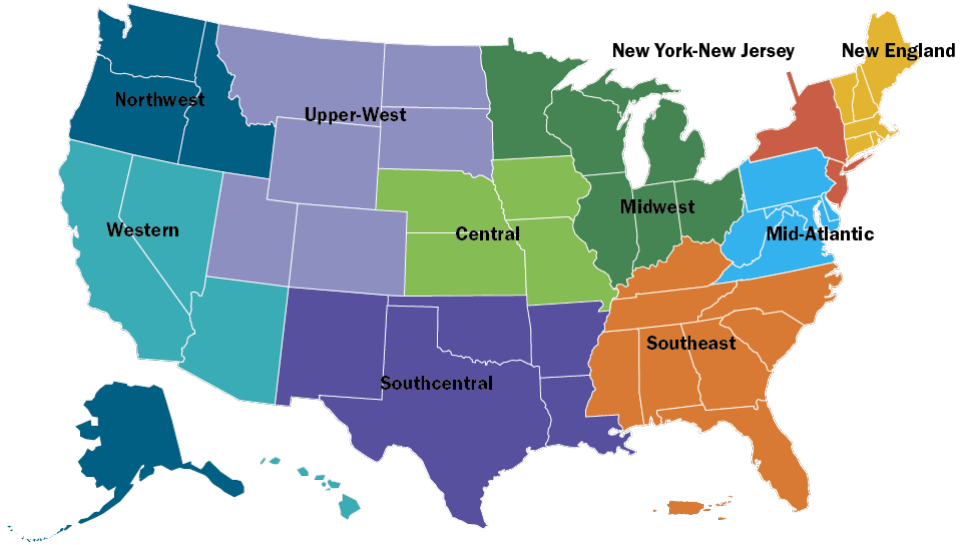


Prepared by Entropy Research, LLC, 11/1/2022

IEDO Onsite Energy and CHP Deployment Programs

- Leverage existing regional CHP TAP program model and expand to include a broad range of clean onsite energy technologies to meet decarbonization goals.
- Strategically focus CHP activities on heavily fossil geographies, hard to decarbonize industries, sites with long-term resilience requirements, and facilities with flexible fuel outlooks.
- Pair deployment priorities with R&D investments to prepare for the future by addressing challenges with renewable fuels and developing technologies for flexible grid connections.

DOE CHP Technical Assistance Partnerships



New Implementation Grant Program includes CHP

APPLY NOW: DOE Industrial Assessment Centers (IAC) Implementation Grant Program - Round 1 Solicitation

Round 1:
$80 million

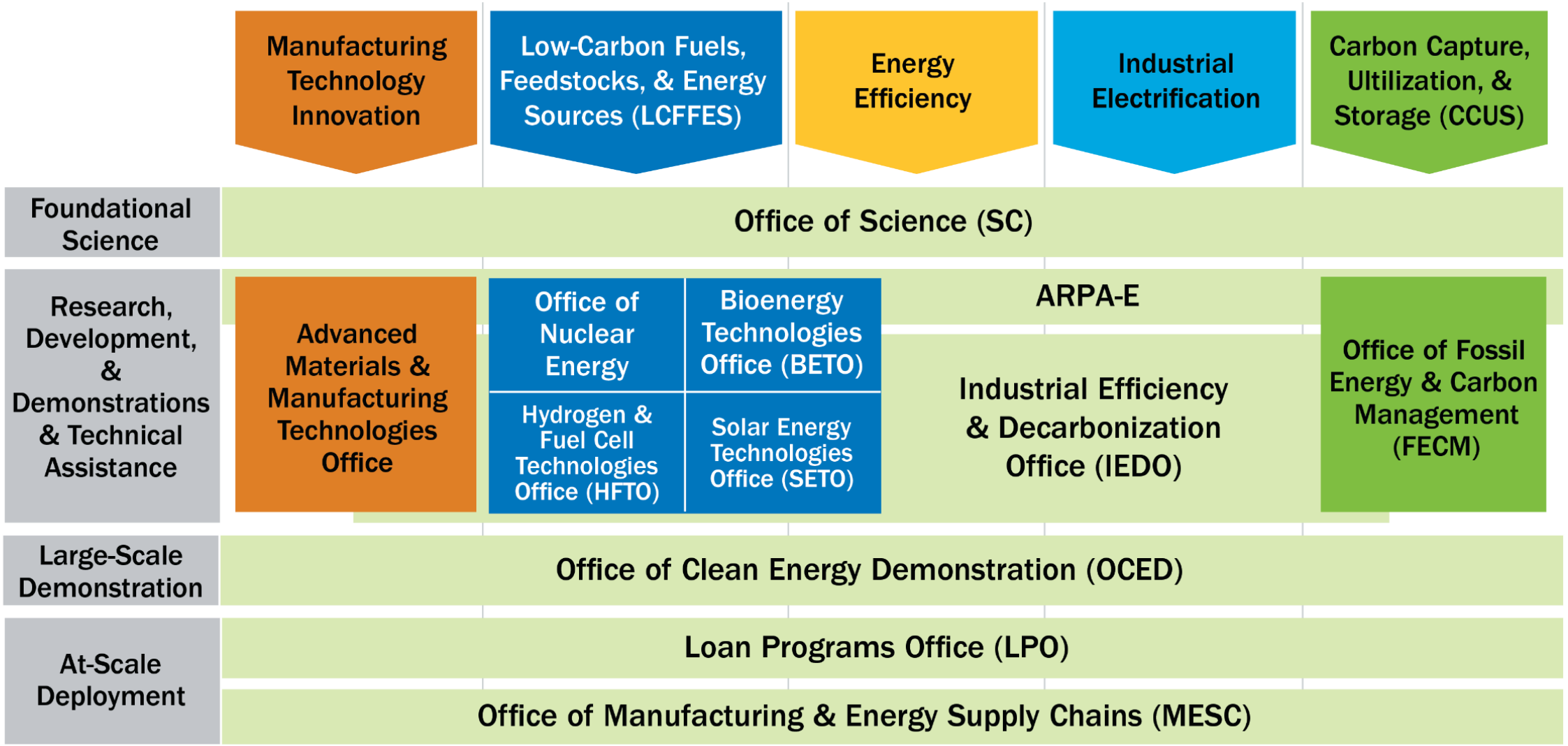
Deadline:
July 14, 2023

- $400M in funding available through FY 2026
- Grants awards of up to $300,000 per manufacturer
- Eligibility exclusively for small- and medium-sized[1] manufacturing firms
- To address recommendations by IACs, DOE CHP TAPs, or other assessments deemed equivalent by DOE

1. Small and medium-sized manufacturer is a firm with: a gross annual sales of less than $100M, fewer than 500 employees at the plant site, and annual energy bills between $100,000 - $3,500,000

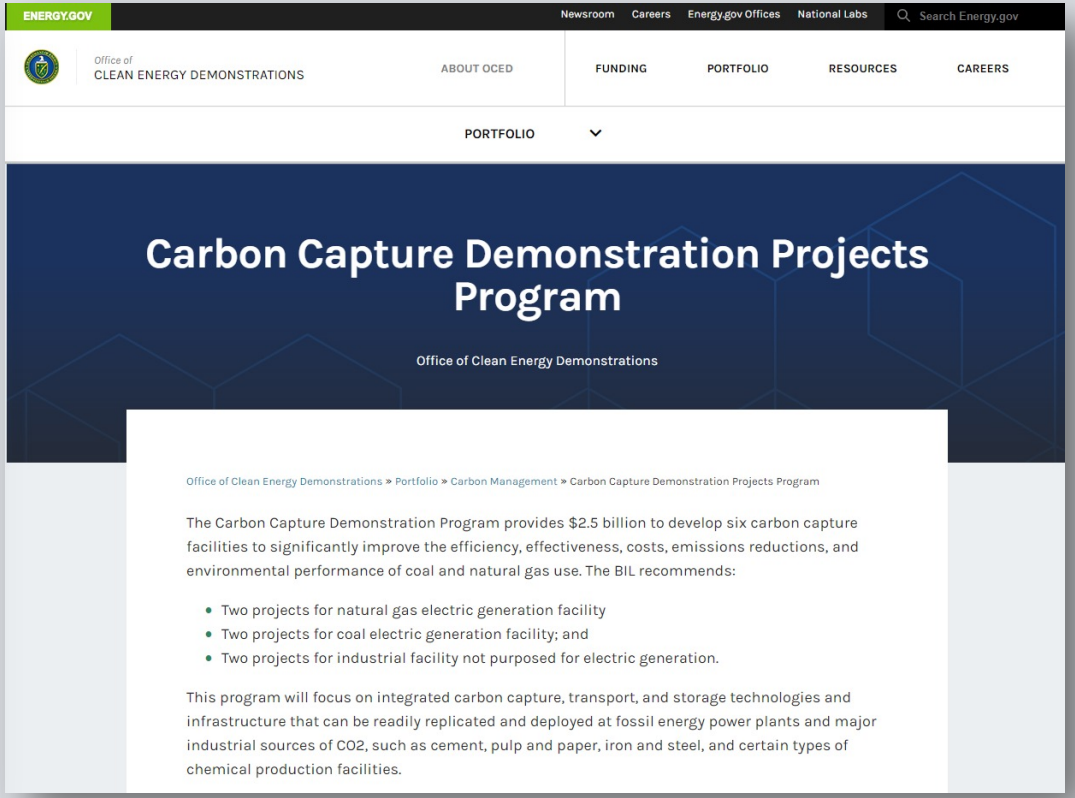
Details: https://go.ratio.exchange/opps/challenge.cfm?i=387AF1B5-410E-4974-BCEC-901EA565045C

DOE Office Coordination on Industrial Decarbonization

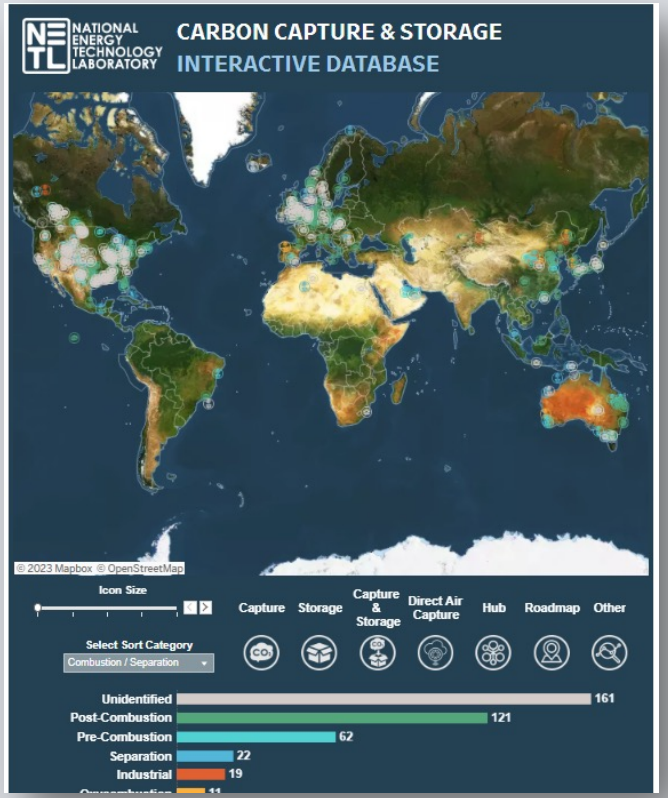


Highlighting Carbon Capture Activities Across DOE

https://liftoff.energy.gov/carbon-management/



https://www.energy.gov/oced/carbon-capture-demonstration-projects-program



https://netl.doe.gov/carbon-management/carbon-storage/worldwide-ccs-database

Thank you

Email: Meegan.Kelly@ee.doe.gov

For additional information and to subscribe for updates:

manufacturing.energy.gov

CarbonQuest

Distributed Carbon Capture for the Built Environment

Addressing the “hard to abate” buildings

Heavy Industry
Large Manufacturing
District Steam
Food & Beverage
Universities
Hospitals
Commercial/Mixed High Rise
Residential/Mixed High Rise
Walk up apartments
Retail
Single Family

20% US carbon emissions from natural gas in large buildings

Over 1GT annually of CO2 emissions from natural gas in 700,000 large & diverse buildings

336,000

Commercial buildings

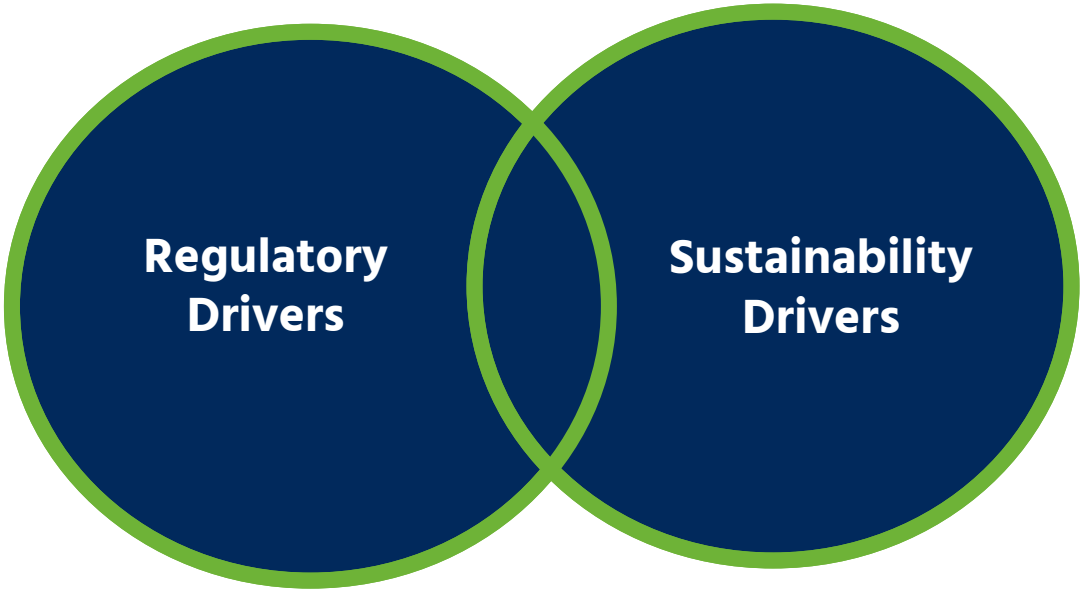
300,000

Industrial buildings

77,000

Multifamily buildings

Decarbonization Regulations & Goals – Compelling customers to action



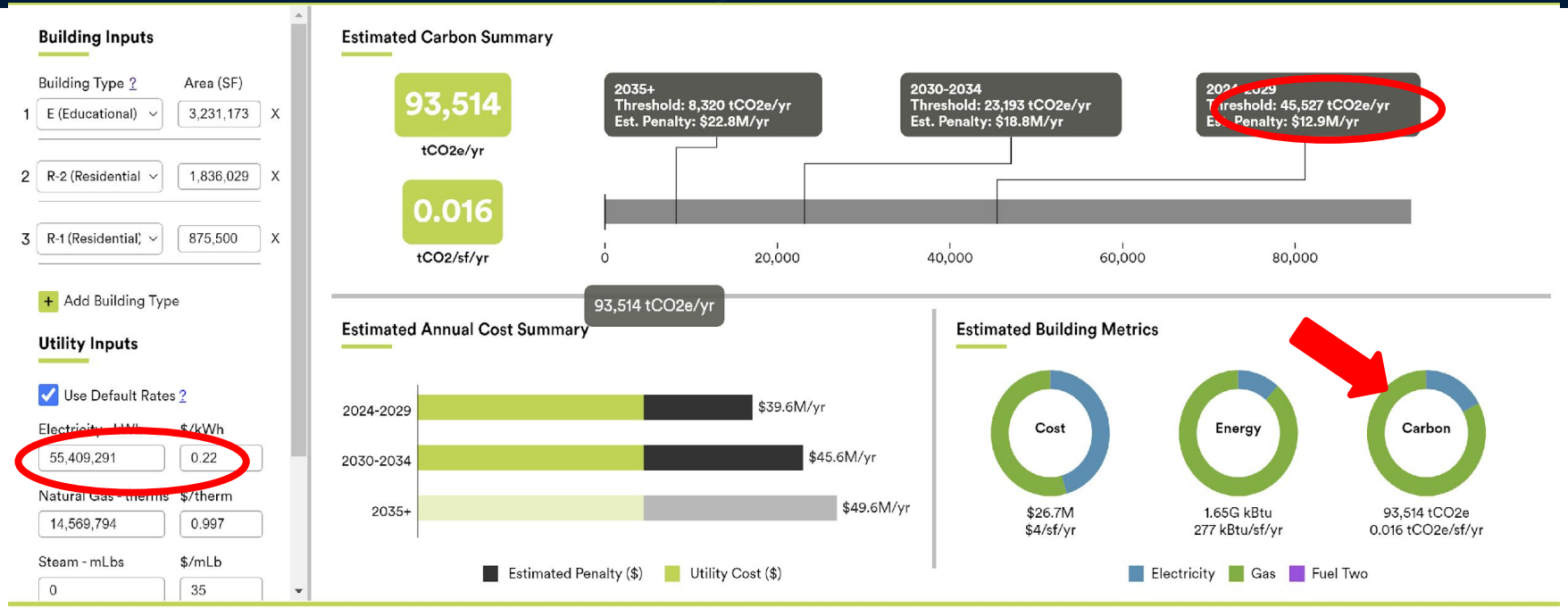
Significant Impact & Economic Opportunity

Significant Variety and Power of US CHP Installations

	Total	
Primemover	Sites	MW
Boiler/Steam Turbine	177	6,215.8
Combined Cycle	180	41,087.1
Combustion Turbine	390	9,546.5
Fuel Cell	127	82.6
Microturbine	422	137.7
Reciprocating Engine	1,997	1,689.8
Other	7	9.9
Total	**3,300**	**58,769.4**

Source: US DOE Summary CHP Dataset

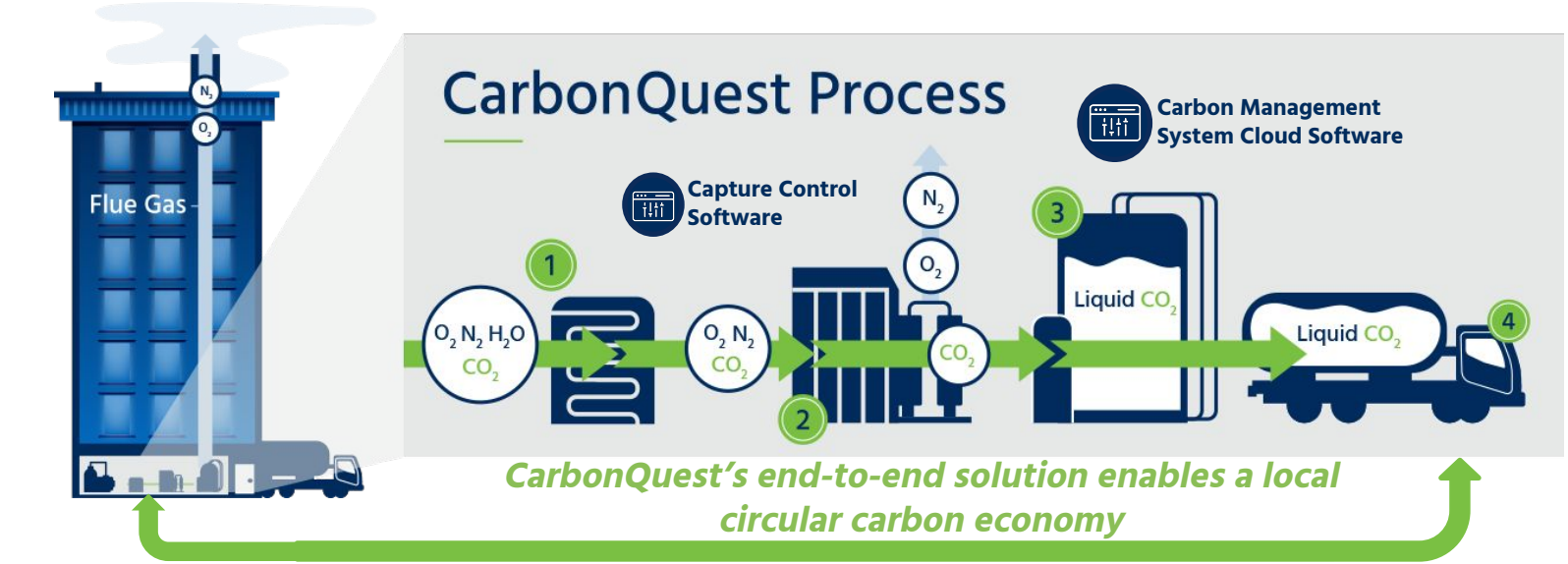
Property with Cogen/CHP with significant natural gas emissions



What now? Visit **NYC Accelerator** for free, personalized advisory services to improve building energy efficiency and lower carbon emissions.

Calculator engine by AKF Group LLC

Solution to Emissions from Natural Gas: Building Carbon Capture

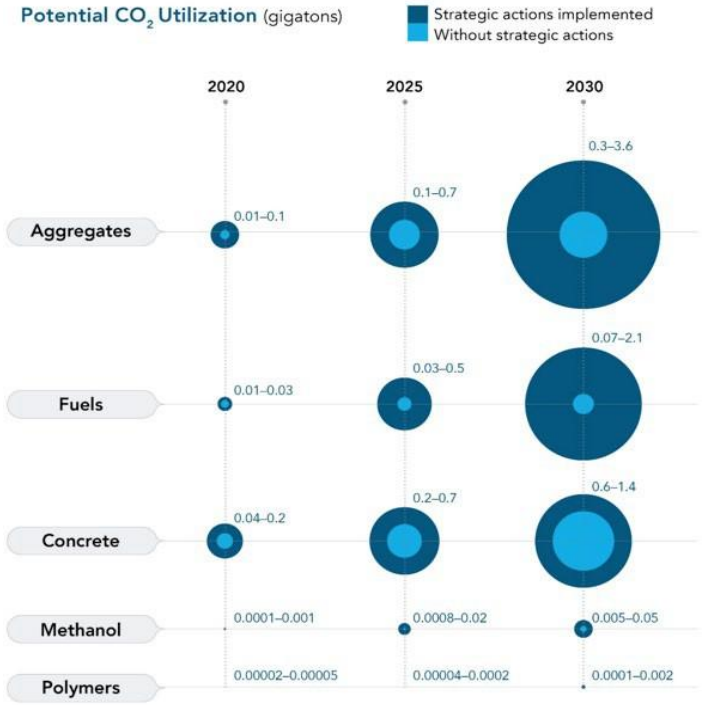


1 | Extraction 2 | Separation 3 | Conversion 4 | Utilization

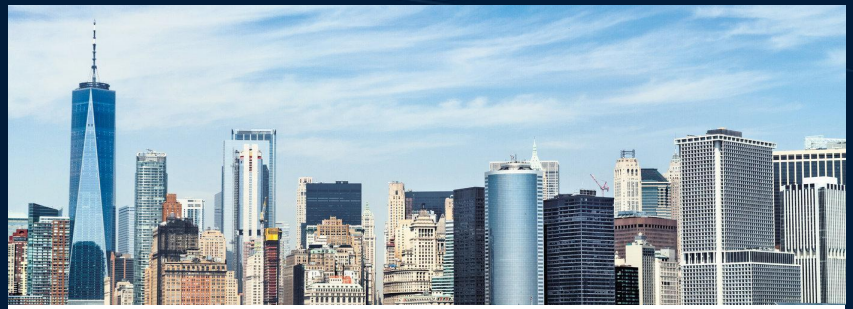
CO2 Market utilization is a huge market

Total market for CO2 utilization with permanence or petroleum displacement is forecasted to grow to $1.3 trillion by 2030 globally.

MARKET SIZE: $ BILLION	2020	2025	2030
Concrete	60	200	400
Fuels	5	60	250
Aggregates	4	30	150
Algae Ag/Feed Products	3	10	120
Algae Fuels/Chemicals	2	4	200
Polymers	1	3	25
Commodity Chemicals	0	5	12



Value proposition for customers



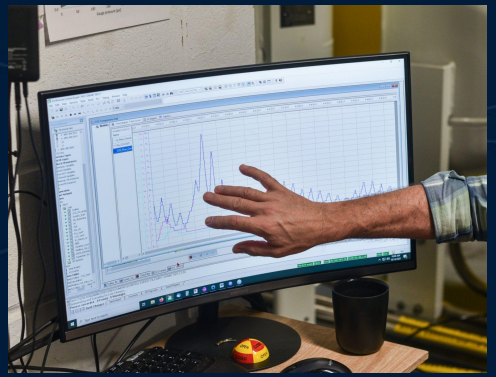
For building owners

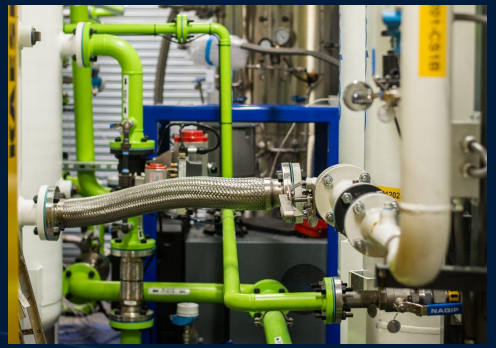
- Immediate decarbonization solutions with onsite Carbon Capture
- Cost effective
- Non-disruptive to operations
- Measures impact and report emissions and reductions (ie LL97)
- Improving the “E” in the ESG performance

For CO2 users

- Lower carbon footprint than most competitors
- Recycled CO2 rather than newly sourced for the market
- Competitive pricing
- Local
- Security of supply for the CO2 strapped U.S. market

Example New York, NY installation

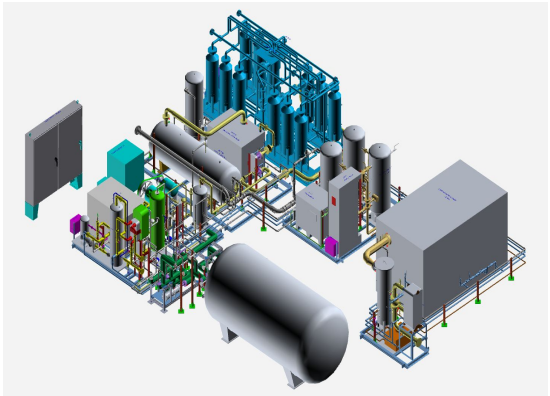




CHP + Carbon Capture = Great Match

To date: more efficient, cost effective, resilient energy and power

Now: more efficient, cost effective, resilient, decarbonized energy and power



CarbonQuest

We would love to answer any questions you have

info@carbonquest.com

New York City, New York | Spokane Valley, Washington | Washington, DC

Introduction

Clarke Energy
A KOHLER COMPANY
Engineer - Install - Maintain

Vishnu Barran
Sales & BD Manager

June 5th 2023

Agenda

- Clarke Energy
- What is Quad Gen

Brief Company Overview

Authorised distributor for Innio
in 28 countries worldwide

Engineer

Turnkey EPC contractor with civil engineering capabilities

Install

Turnkey EPC contractor with civil engineering capabilities

Maintain

Full maintenance, operation and overhaul services maximising equipment availability

Global Turnover

The company has seen consistent growth over a number of years

$450m

Installed Base

Installed over 7GW of power globally, enough to power 17 million UK homes

7.9GW$_e$

Diversification

Power Solutions provider with experience in a range of complimentary technologies

UK Headquarters

Knowsley based company since 1989

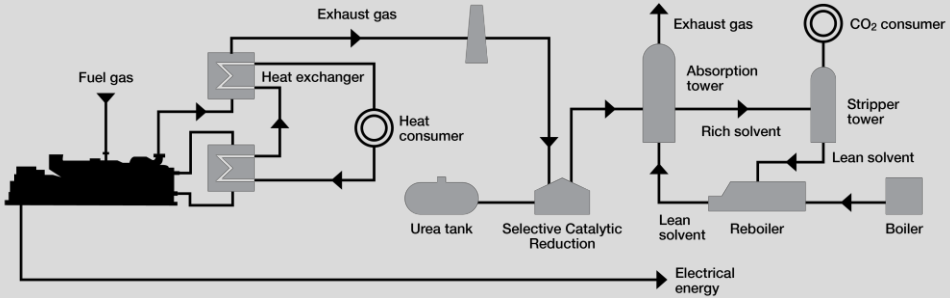
Global Talent

1,200 employees locally deployed

Combined cooling, heat, power and carbon dioxide recovery

Localized generation of electricity, heating, cooling and (up to) food and beverage grade carbon dioxide

Incorporation of heat recovery, absorption chillers plus amine-based carbon dioxide recovery systems



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Quadgeneration: electricity, heat and cooling and CO_2 recovery

Carbon Dioxide Capture and Conversion

Recovery and clean up of carbon dioxide from engine exhausts and separated biogas

Carbon Utilisation

Supporting Net-Zero

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What is Quad-Generation Beverage Grade

- The CO2 extraction-based plants are built on a proven and currently the most efficient amine technology available on the market;
- The Advanced Amine Technology, Is a result of the general requirement of high purity CO2 sources and the need for solutions tolerant for high O2 content / CO2 sources >3%, the Advanced Amine Technology is increasingly popular.
- The AAT Reduces carbon footprint and it is an independent CO2 plant, offering the value of on-site production and the highest purity Beverage grade CO2.

Some of the advantages with the Advanced Amine Technology are:

- High CO2 reaction rate
- Can tolerate high oxygen content (15%)
- Lower energy demand for re-generation
- Lower total energy demand
- On-site production off-setting road transported CO2
- Reducing carbon footprint

Amine washing process – Deep dive

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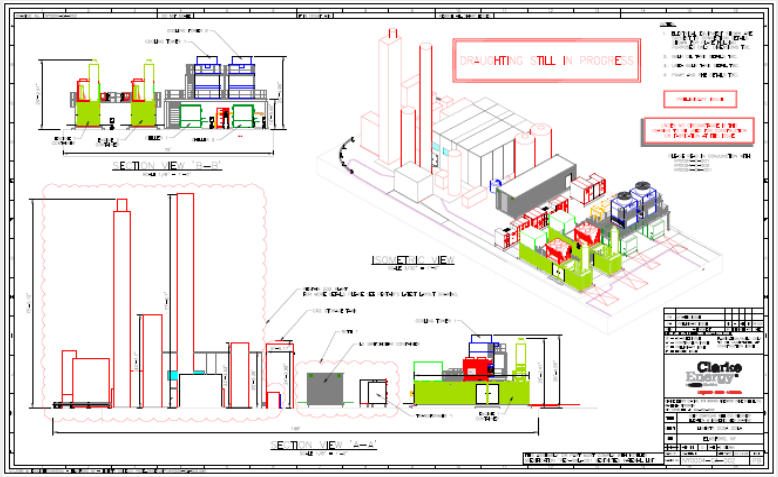
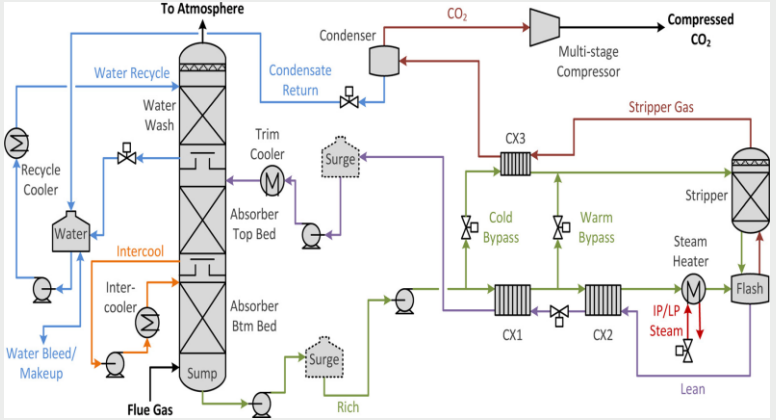
- The flue gas is lead to the SCR catalyst (De-Nox unit) for removal of nitrogen oxides NOx.
- After the SCR catalyst the hot flue gas is transported to a MEA reboiler.
- The flue gas scrubber is used for cooling and washing of the gas by re-circulating water over a packed bed.
- The treated flue gas enters the extraction unit in the absorber tower.
- The gas flows through the packed bed sections of the absorber tower.
- The MEA solvent reacts chemically with CO2, absorbing 80-90 % of the CO2 in the incoming flue gas.
- Residue gas, mainly N2 and O2, is vented through the top of the absorber.
- The residue gas enters the absorber tower where it is cooled and cleaned in a wash section and entrained MEA is removed and returned to the absorber tower.
- The rich MEA solvent (CO2 saturated) is pumped from the bottom of the absorber to the top of the stripping tower.
- It is preheated in the lean/rich solvent cooler before entering the stripping tower.
- In the stripping tower the rich MEA solvent is further heated in a re-boiler by means of hot flue gas and the chemically bound CO2 is released from the MEA solvent.
- From the stripper column the lean MEA solvent is returned to the absorber tower through the rich/lean solvent cooler.
- The lean MEA solvent is cooled in two stages,.
- To maintain the highest possible absorption capacity of the MEA solvent, contaminants, such as heat stable salts, are removed in a re-claimer. The reclaiming process is operated in batches.





Amine Process – Deep dive

- The lean MEA solvent is led through a carbon bed in order to remove solution contaminants
- The CO2 gas leaves for the liquefaction unit through the gas cooler
- The CO2 gas enters the liquefaction unit to wash out any possible carryover of MEA.
- The gas is compressed using a double stage compressor.
- The compressed gas is cooled in the compressor aftercooler before being dried in the dehydrator.
- The dehydrator will also remove any potential traces of oxygenates such as aldehydes.
- The dehydrator is followed by an activated carbon filter which will remove any smelling substances from the gas.
- In order to ensure the highest possible purity of the CO2 the plant is supplied with a purification system.
- The CO2 gas from the activated carbon filter is led through the re-boiler of the purification unit where it is cooled before it continues to the CO2 condenser.
- The condensate from the CO2 condenser flows by gravity to the top of the purification column, The refrigeration plant is designed to maintain a steady pressure in the CO2 condenser.

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CHP for Greenhouses

Onsite electricity, heating, cooling and CO2 air enrichment for greenhouses.

Carbon Utilisation

Energy Efficiency

Energy Resilience

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KOHLER
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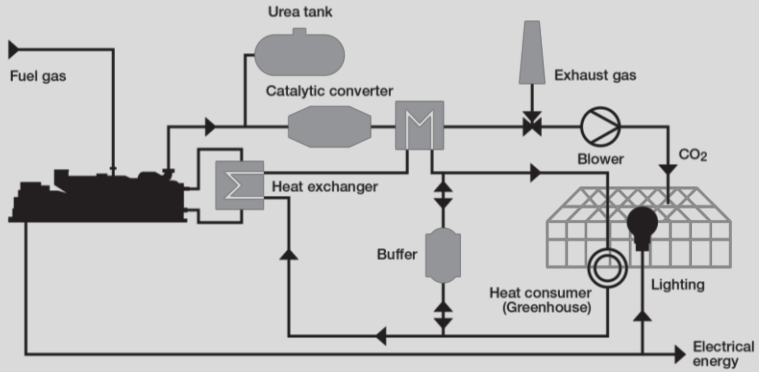
Combined Heat and Power with CO_2 Air Enrichment for Greenhouses

Localized generation of electricity, heating, cooling and (up to) food and cleaned carbon dioxide to enrich growing air of the greenhouse

Incorporation of heat recovery, thermal storage and catalyst-based exhaust gas clean up



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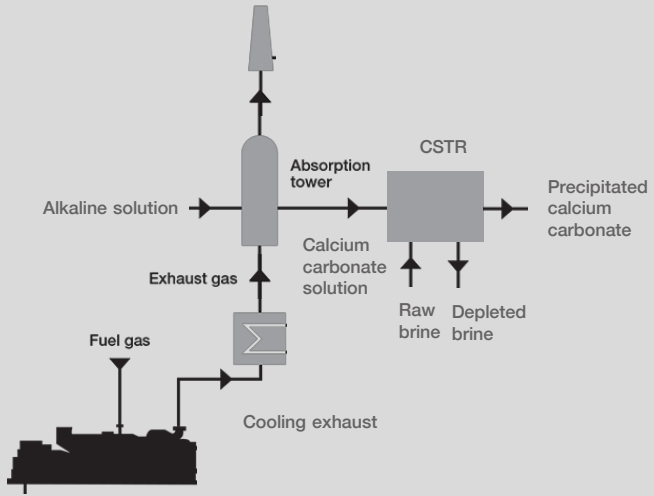
Energy efficient heating and electricity for greenhouses + CO_2

Advanced Mineralisation [Proof of Concept]

Mineralisation of carbon dioxide to high grade precipitated calcium carbonate

Utilisation of brine and alkaline solutions



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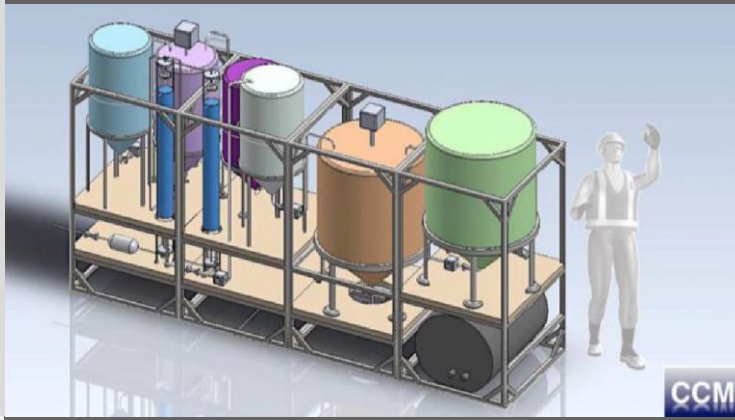
High grade calcium carbonate



NEXT STEPS

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- Free Feasibility and Budget proposal by Clarke Energy.
- Client presentation for Go/no Go
- If Go. Engineering deposit for Executable proposal. Drawings, Plans and Spec's produced to ensure no scope/price gaps for Clarke EPC (Turnkey) proposal.
- Submit final proposal to Client. Go to mutual contract to "build the job"
- System installation by Clarke. Start-up , commission and hand over to client.
- Client training by Clarke
- Operations & Maintenance by Clarke for the entire system (If req'd)

Feasibility Analysis

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A **detailed feasibility** study is **essential**

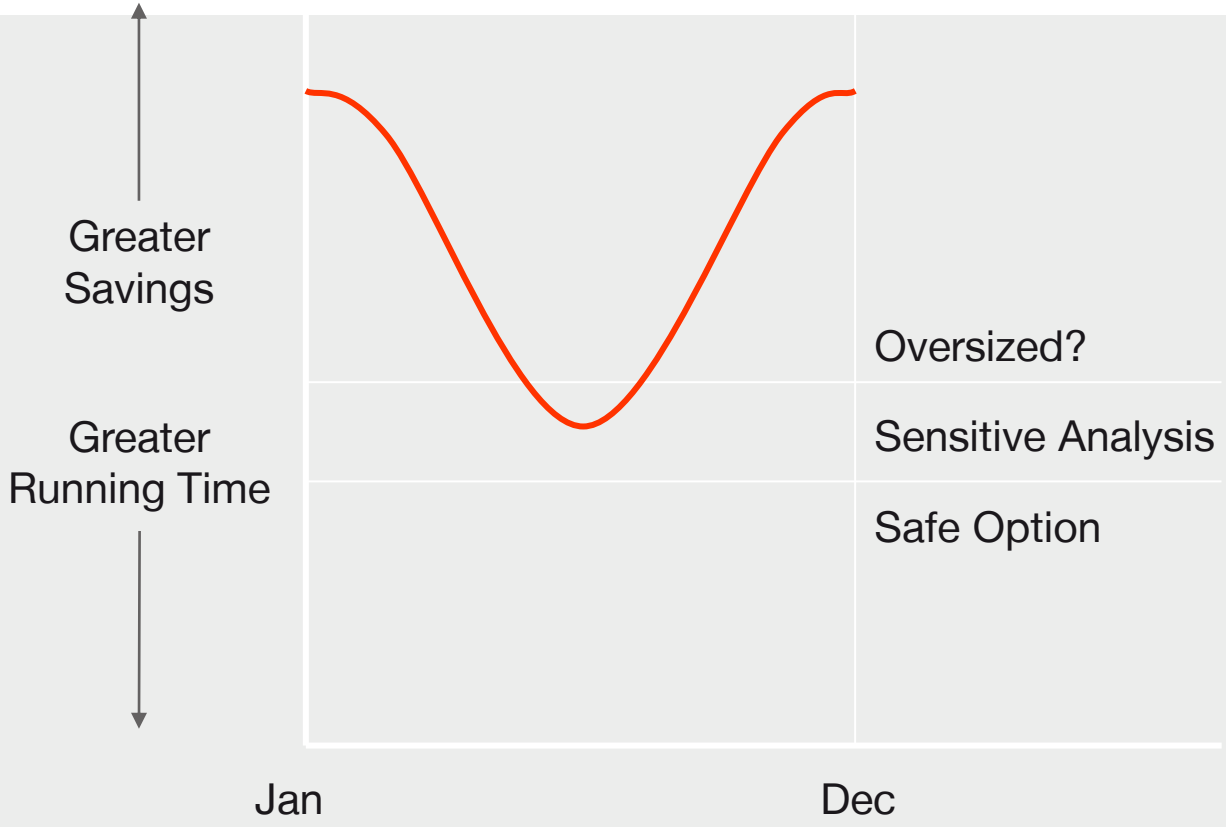
To fully appreciate the project **all loads need** assessing

To realise maximum benefit, operation needs to be maximised – **availability** and **reliability** key

Consider what **assumptions** have been used

Assess full **life-cycle financial** and **environmental savings**

Analyse a **suppliers' capability to deliver** (reference sites, infrastructure) as well as their technical offering



Flexible delivery model

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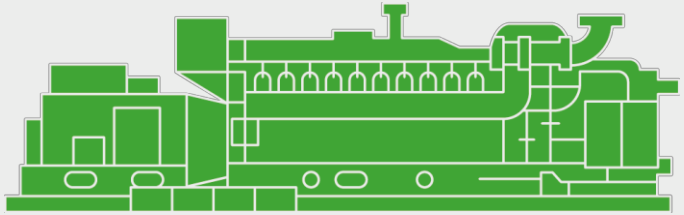
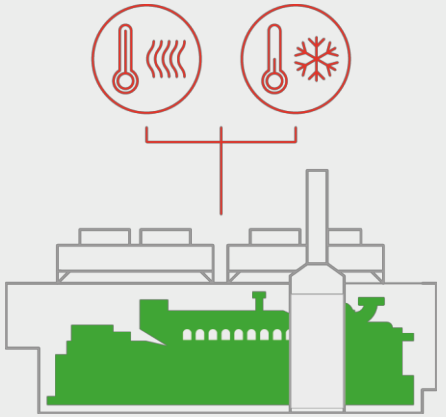
Gas genset

A Jenbacher (or MAN) genset is configured to produce electrical power only



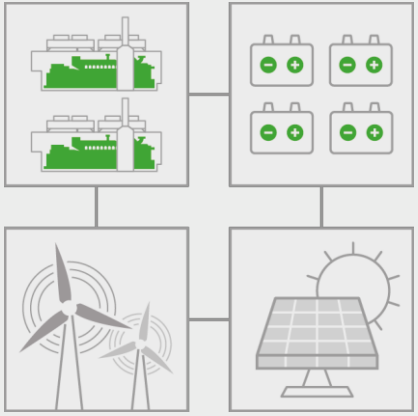
Power module

A Jenbacher gas engine module is configured for the recovery of both electricity and heat



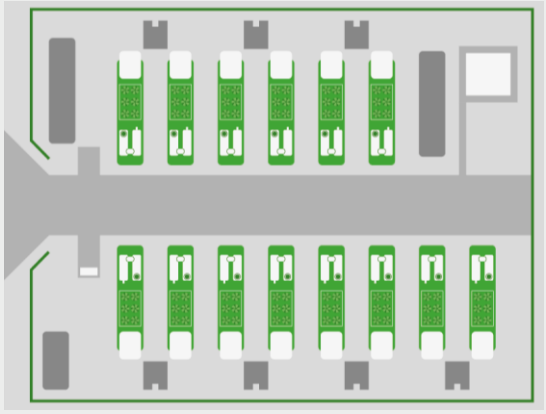
Hybrid solutions

Clarke Energy can take on a greater scope of project supply and incorporate different power generation technologies



Power plant

Clarke Energy can supply a turn-key installation of a multi-engine power plants



Coca Cola Hellenic, Northern Ireland

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Natural gas for Industrial customer

Electricity with Steam, Hot Water, Cooling and Beverage grade CO2

15,000 kW_e

5 x JMC620
1,500 kg/hr CO2
Or approx. 12,000Tons/yr

Coldwater Board of Public Utilities, Michigan, USA

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Natural gas used for cogeneration in greenhouse application

Electricity, heat and option to recover CO_2 for plant growth

13.2MW$_e$

3x J624

For Further info.

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NE CHAPTER
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Q&A Discussion

NE CHAPTER

OF THE COMBINED HEAT AND POWER ALLIANCE

Thank You!

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