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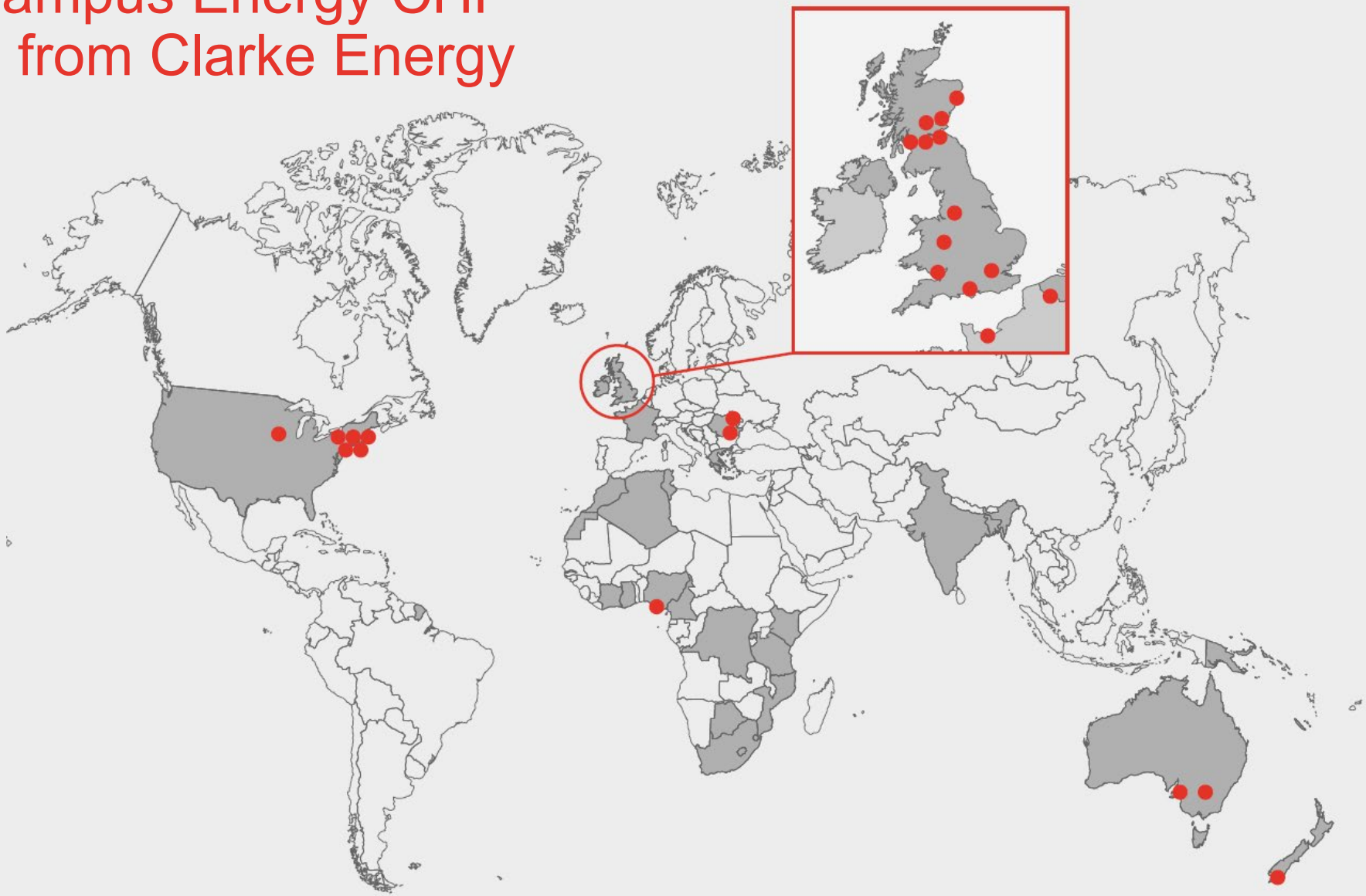
Global Innovations in CHP-Based District Energy; Hydrogen, Carbon Capture and Heat Pumps

Alex Marshall, Group Director, Clarke Energy

December 6, 2022

Global Campus Energy CHP Facilities from Clarke Energy



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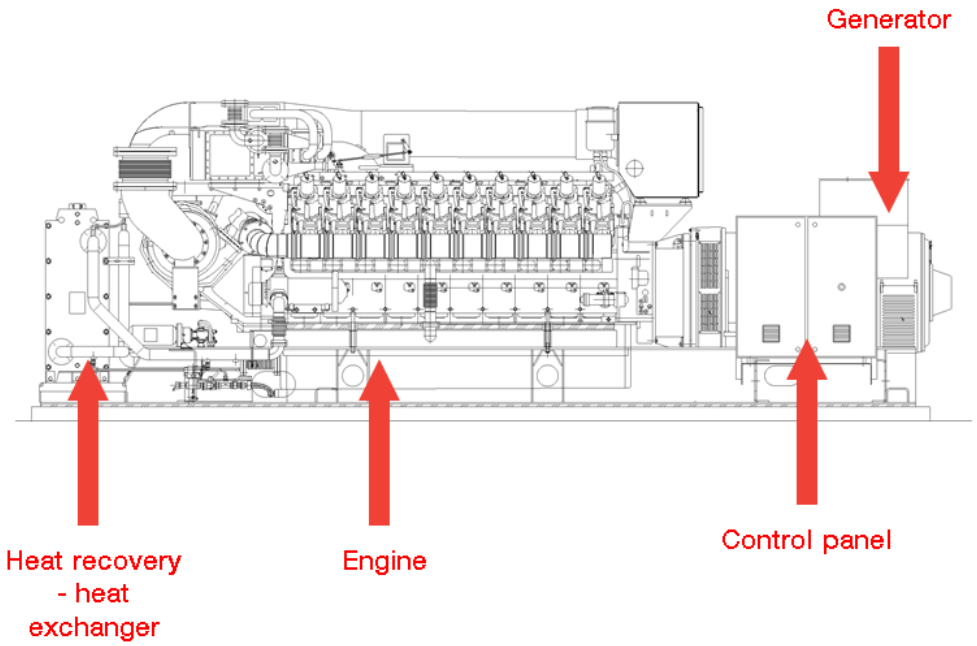
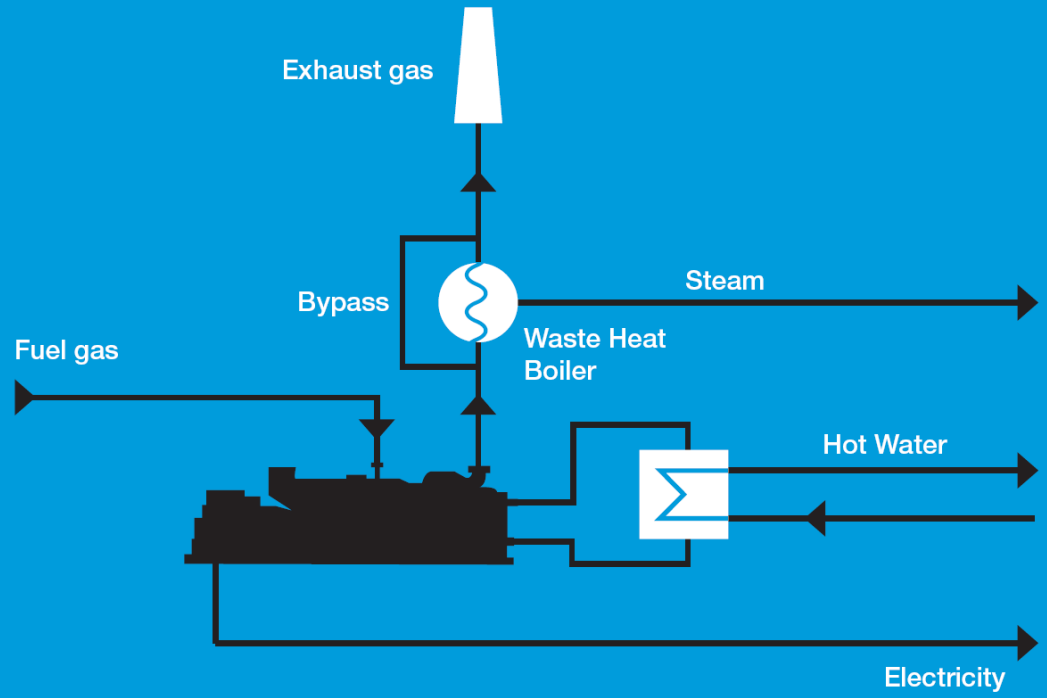
Combined Heat and Power

Combined Heat and Power Basics

Gas engine module

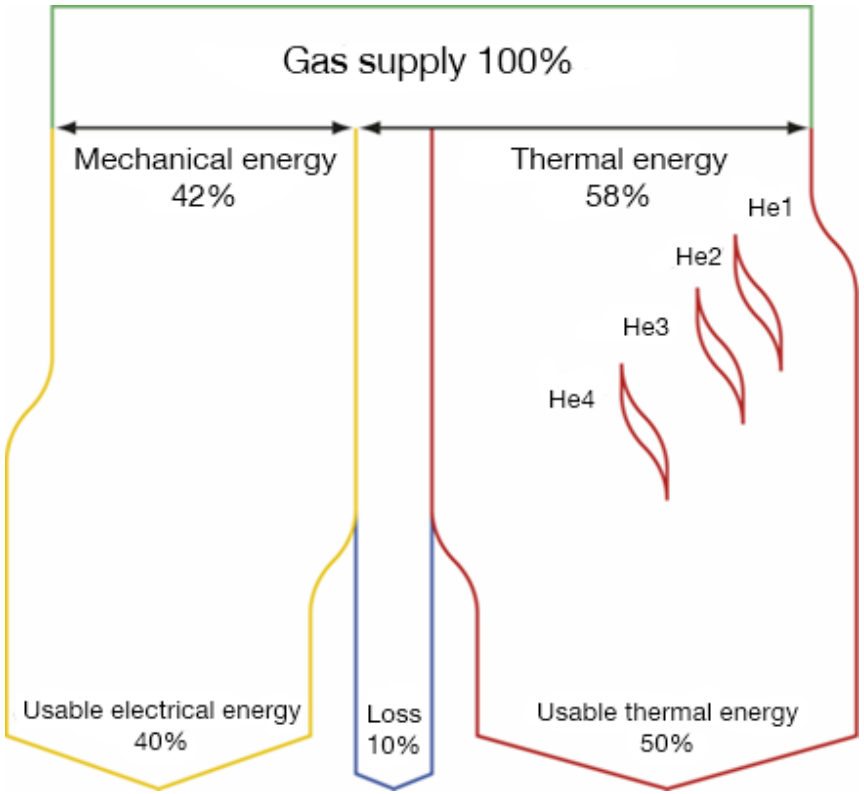


CHP Process Flow

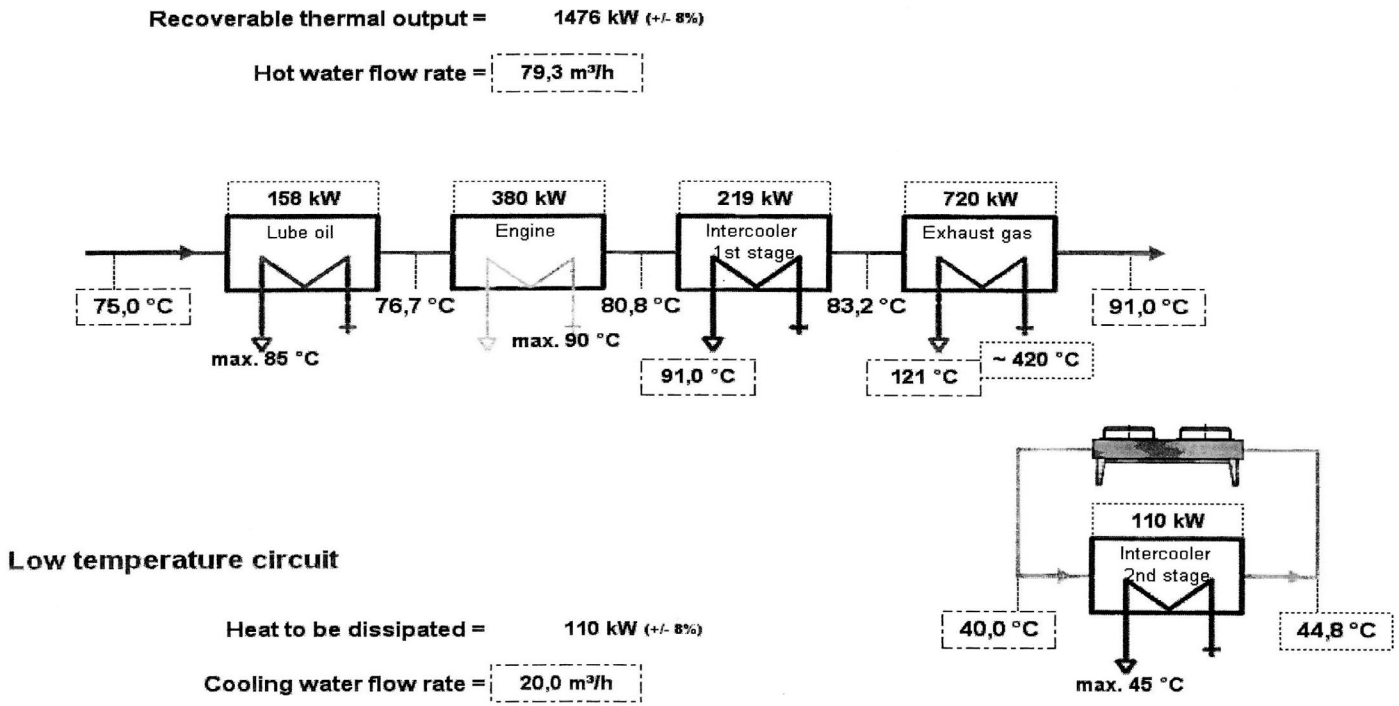


Combined Heat and Power Basics

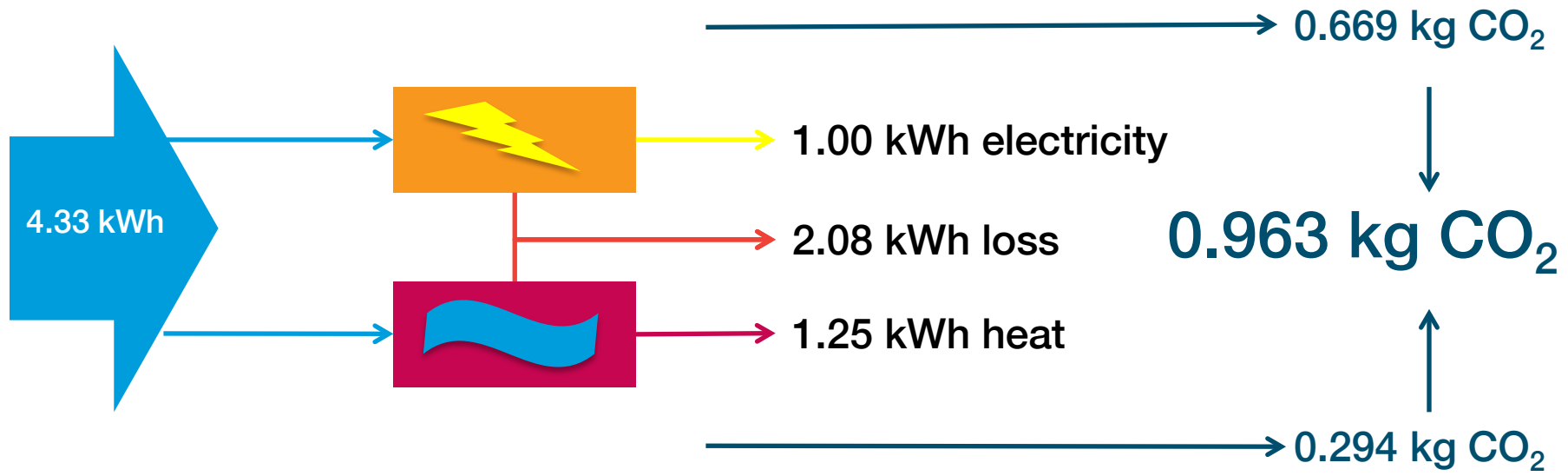
Simplified Energy Balance



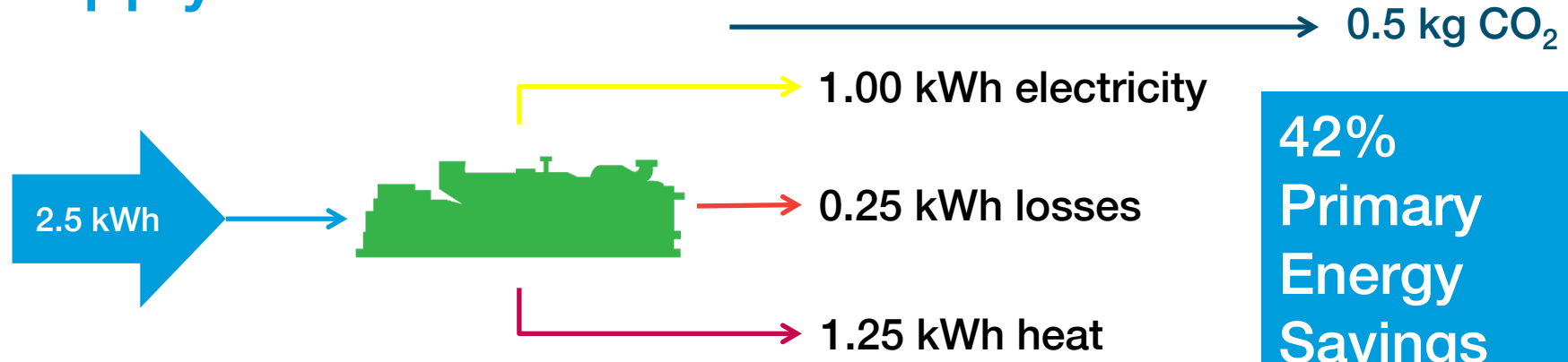
Example of CHP Thermal Recovery



Example Natural Gas CHP CO_2 Reduction



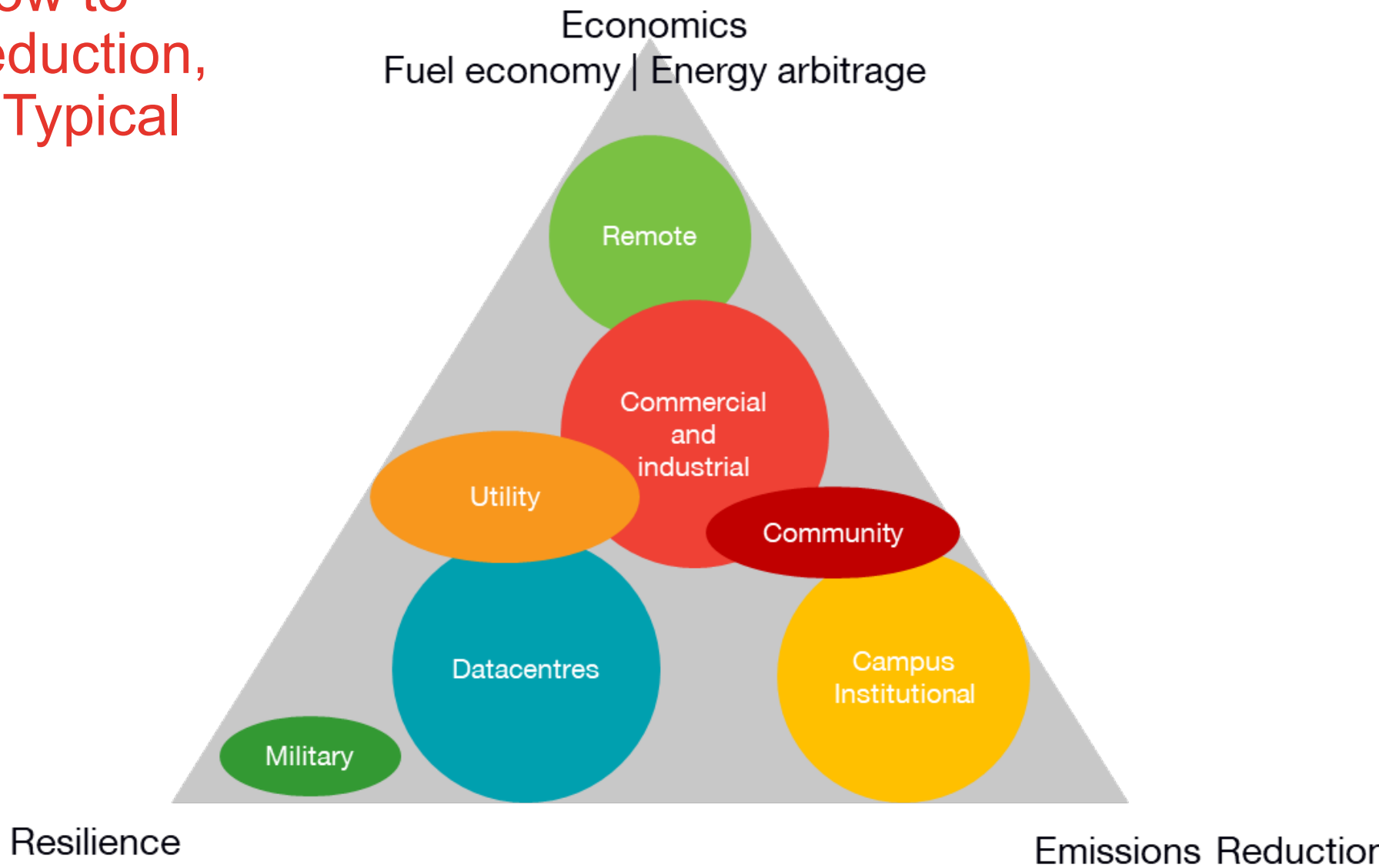
Gas Supply



42% Primary Energy Savings

48% CO_2 reduction

The “Trilemma” – How to balance emission reduction, cost and resilience. Typical End User Focus.



Boston Public Schools, Boston, Massachusetts

- Combined heat and power
- 25 schools and educational facilities across Greater Boston
- 70-250kW gaseous fuel engines packaged in Upton, Massachusetts
- Pipeline natural gas fuel originally supported by local incentives
- Various sites installed 2004-2019

Glasgow Caledonian University District Energy CHP Plus Educational Facility

- Combined heat and power plus CHP teaching and demonstration facility
- Glasgow Caledonian University, Scotland
- 845kW Jenbacher CHP engine
- Pipeline natural gas fuel originally supported by local incentives
- Installed 2013
- “Highly Commended” by CHPA Awards

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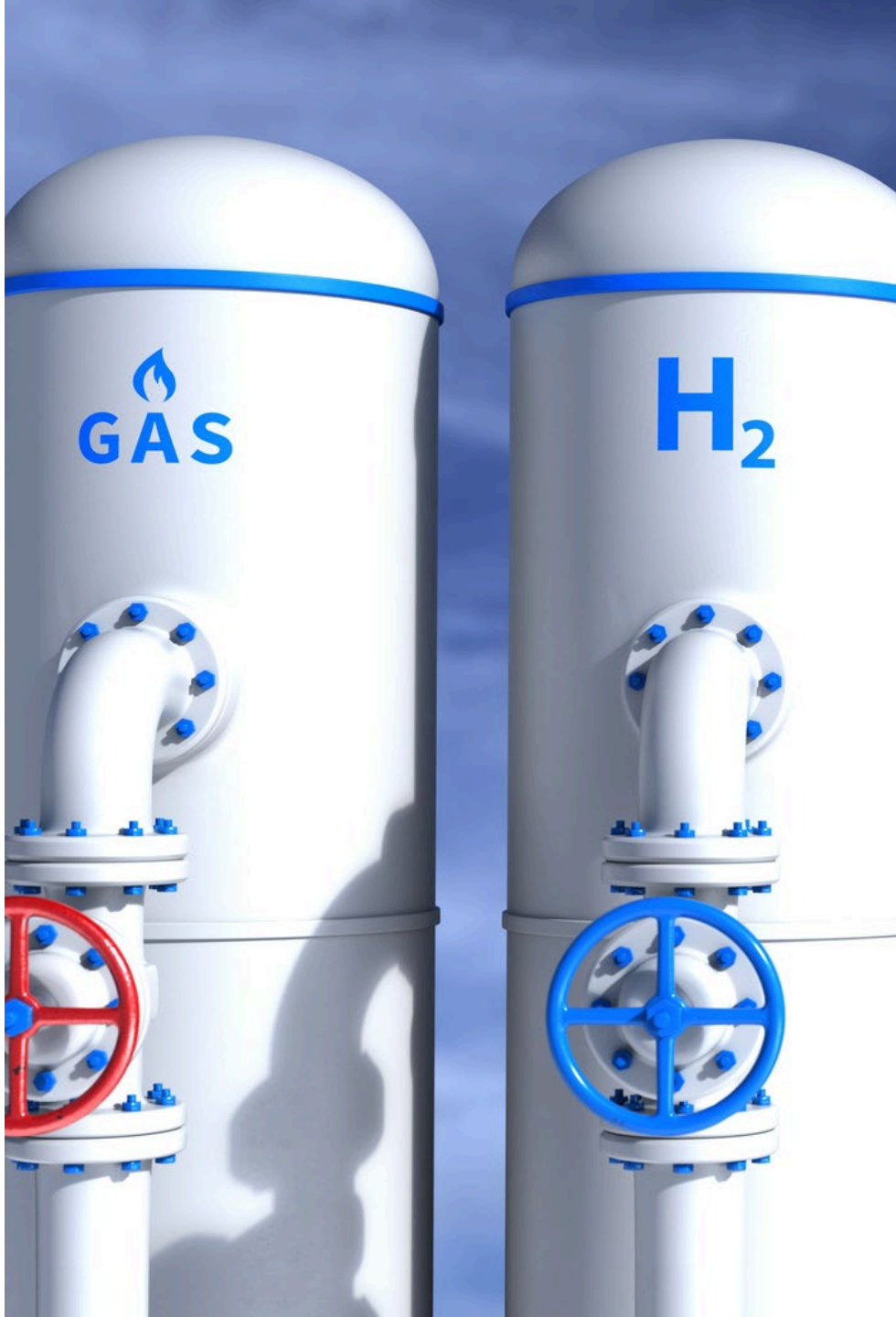
Combined Heat and Power – The Next Generation

Key Current and Future Fuel Options

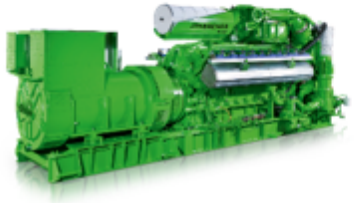
- **Renewable Natural Gas**
- **Biogas**
- **Hydrogen**
- **Natural Gas**
- **+ Blends of the Above**



Hydrogen Options for INNIO's Jenbacher Gas Engines

A

H_2 in natural gas pipeline

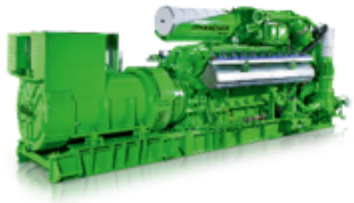


A-1: Low H_2 blending
Optimised for natural gas
<5% H_2 (v/v)

A-2: Medium H_2 blending
Broadband product
5-20% H_2 (v/v)

B

H_2 local admixing



B-1: Special gas engine
Operational optimized
up to ~60% H_2 (v/v)

B-2: Natural gas / H_2 engine
Dual gas engine to 100% (v/v)
Natural gas / H_2

C

Pure H_2

C: H_2 engine
Hydrogen engine (H_2)
100% H_2 (v/v)

Conventional natural gas + H_2 fuel mixture boosted system

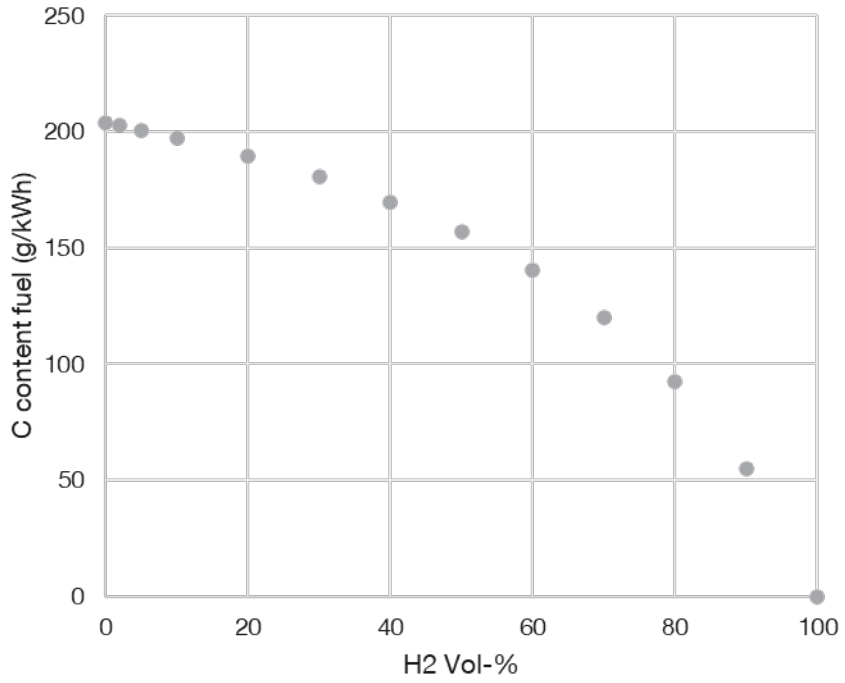
H_2 fuel injection system

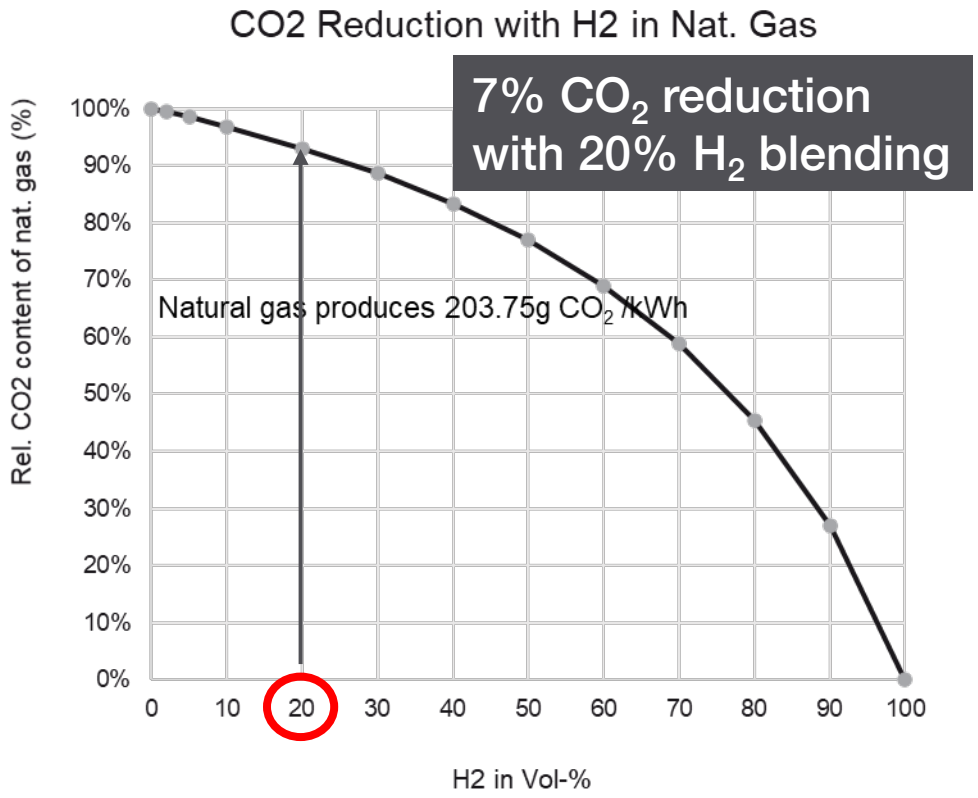
Available for existing versions	Available for existing versions	Available for existing versions	Special release engines available	Special release engines available

Source: INNIO Jenbacher 2022

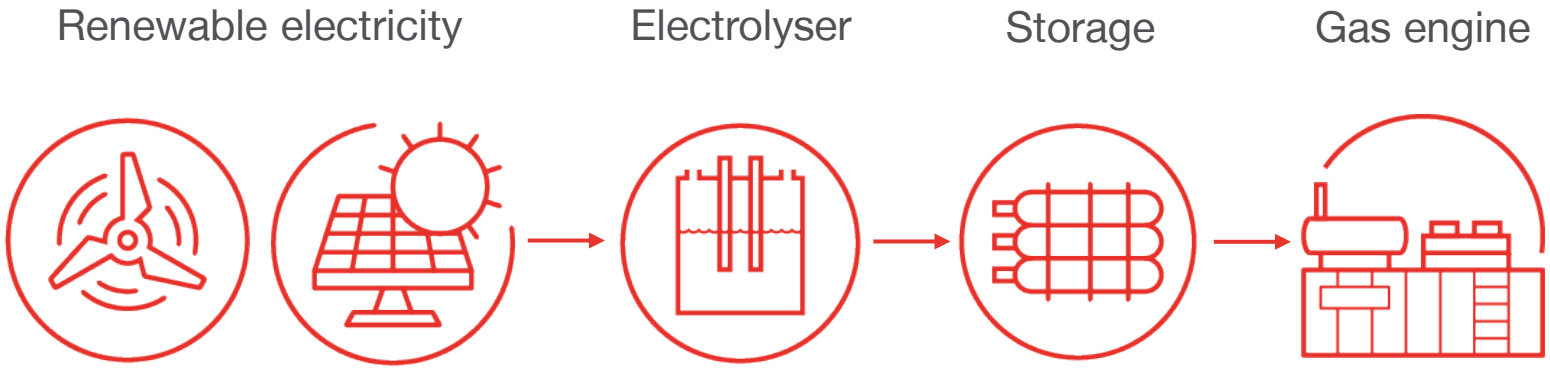
JENBACHER
INNIO
Distributor Now Units & Services

CO_2 Emission Reduction for Hydrogen / Natural Gas Blends





Potential to Link Electrolyzers with Hydrogen-Fuelled Gas Engines



H_2 blend (%)	Renewable Electricity (MW_e)	Electrolyser (kg H_2 / hr)	Gas engine (/MW_e)	CO_2 saving vs 100% natural gas (%)
20%	0.25	5	1	7
50%	0.80	16	1	22
100%	3.75	75	1	100

Carbon Dioxide Recovery, Capture, and/or Conversion Options for Campus Energy

Technology	Catalyst	Amine	CCUS
Output	NO_x removal, CO_2 enrichment	High grade CO_2 recovery to food or beverage grade	Mineralisation of CO_2 to high grade calcium carbonates
Typical application	Greenhouses	Soft drinks manufacturer	CHP, wastewater treatment
Typical input		Amines	Brines

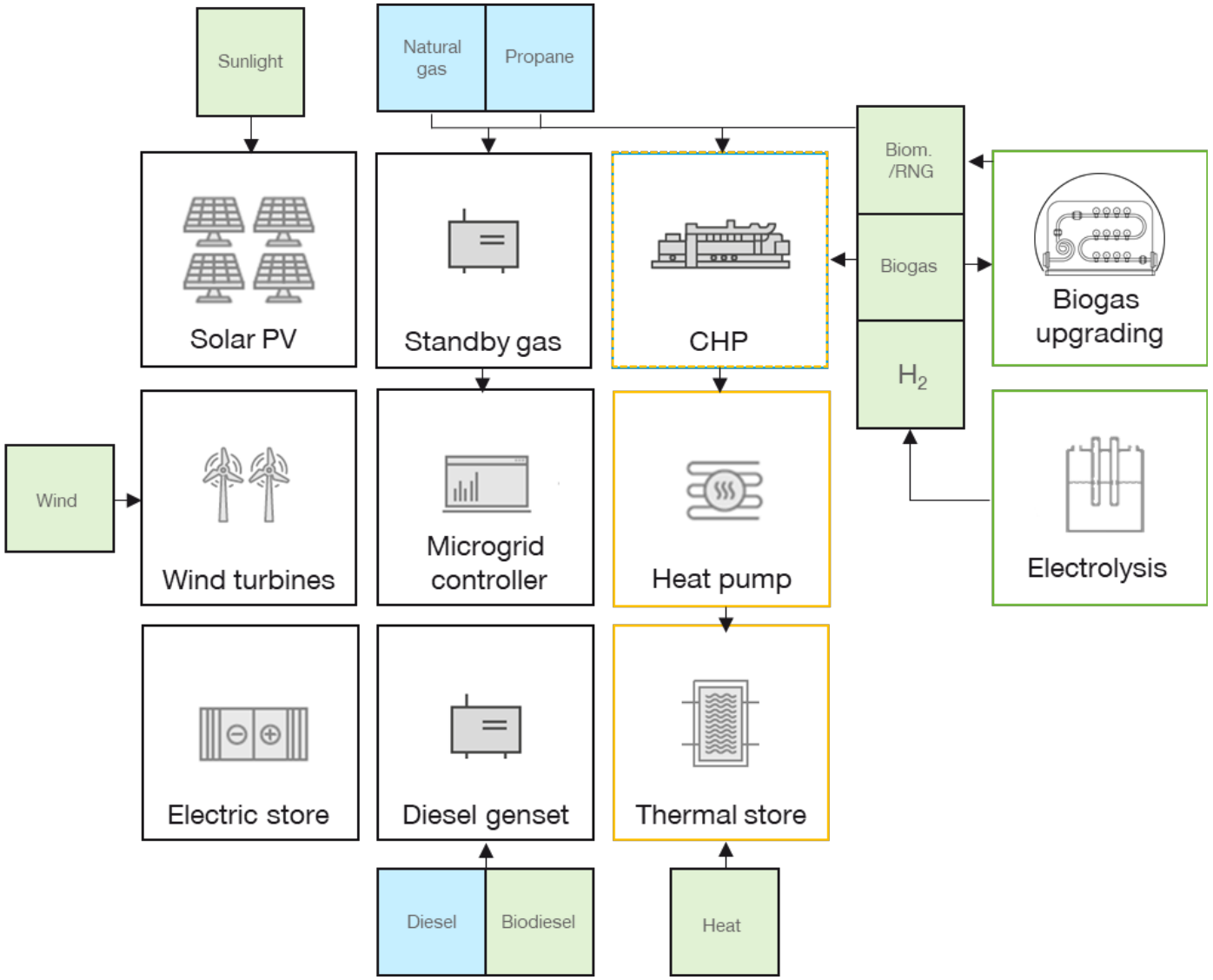
Planned Carbon Negative Biogas CHP Unit, Severn Trent, United Kingdom

- Biogas CHP units at a UK, wastewater treatment site, grant awarded 2022.
- 2023 engineering and construction commencement
- Consortium including Seven Trent, Carbon Capture Machine (CCM), Clarke Energy, Scottish Water, Southern Water and United Utilities
- 800kW CHP unit plus novel carbon capture machine converting CO2 into advanced calcium and magnesium carbonates

Campus Microgrid

Regional Leads

Key Building Blocks



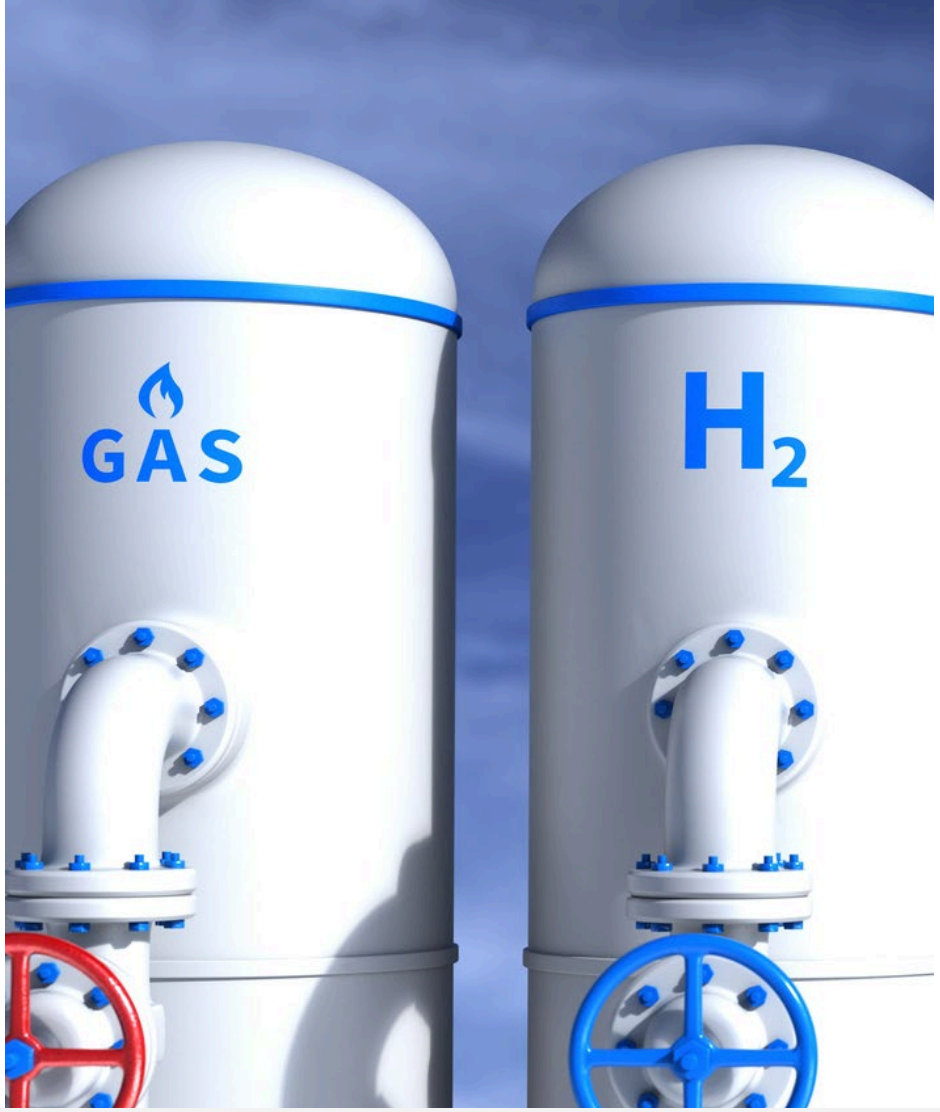
Middletown Recreation Center Microgrid, Middletown Connecticut

- Repurposed site, previously Woodrow Wilson Middle School.
- Recreation Center Office, Gyms, Pools Dedicated Department Building.
- Heating and cooling center for homeless community during extreme weather events.
- 35kW$_e$, 204.1BTU/hr hot water CHP + black start capability, KOHLER KG100 back-up, gas-fueled generator, 10kW battery energy storage system,83.3kW solar photovoltaic array, COMAP controller
- Funding X-Caliber Rural Capital

Linking CHP to Heat Pumps – Chearfarm Glasshouse, UK

- Hybrid gas engine CHP, water source heat pump plus carbon dioxide recovery (catalyst)
- Potential technological application to campus energy schemes
- 3 x gas engines, 9MW electrical output
- 33 MW thermal output from CHP engines plus water source heat pump
- 6,000m3 thermal storages



For More Information Contact

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