Benefits of Cogeneration and Gas Heat Pumps

Vincent Chiocchio
President of Controlled Air, Inc/Yanmar Energy Systems North America

Controlled Air INC.
HVAC, Building Controls & Energy Systems
YANMAR GROUP

Vin Chiocchio
President Controlled Air/Yanmar Energy Systems North America

- Over 45 Years in HVAC Business
- Product Advisory Board for Johnson Controls
- Former Board Member of the CT Green Building Council
- LEED AP
- Designed the MicroGrid for the City of Bridgeport
- Personally responsible for the design or installation of over 25 Combined Heat and Power / Cogeneration systems including multiple Micro-Grids.
- Yanmar Dealer for both Gas Heat Pump VRF Technology and Cogeneration.
- Approved Reseller and installer of Tecogen reciprocating CHP Equipment.

Controlled Air

- Controlled Air, was founded in 1980, as a family-owned and operated heating, ventilation, air conditioning and temperature controls company with 108 employees.
- On October 3, 2022, Yanmar America acquired Controlled Air, Inc. to create a North American center for engineering excellence and service solutions becoming part of their Energy Systems Company.
- In partnership with Yanmar, Controlled Air will continue as a leader in creating environmentally sound, energy-efficient HVAC designs that save money for our customers and promotes the conservation of energy. Controlled Air maintains all the same products and solutions with the addition of Yanmar Energy System product line.
- Controlled Air continues to work with all major manufacturers
- We hold Connecticut State License's # CT S1 302788, MEC 0001131, SM1 0003954, E1 0121932 as well as Rhode Island Refrigeration/Master 1 & Piping/Master1 00007776.Controlled Air, Inc. is a partner of the EPA CHP Partnership Program.

Service & Maintenance

- **Service & Support 24 Hours a Day, Seven Days a Week**
- We create custom maintenance solutions to meet your service needs.
- Our service delivery strategy starts with a thorough preventive maintenance plan, which minimizes repair calls.
- Computer and GPS-dispatched technicians are always on call and enter service documentation via laptop.
- Our fleet of 50 GPS equipped service vans are ready to roll any time of day or night through our computerized dispatch system.
- Our remote diagnostic capabilities can often pinpoint system irregularities and allow for adjustments through computer access. Automatic notification systems can alert us of problems that may be resolved even before you are aware of an issue.

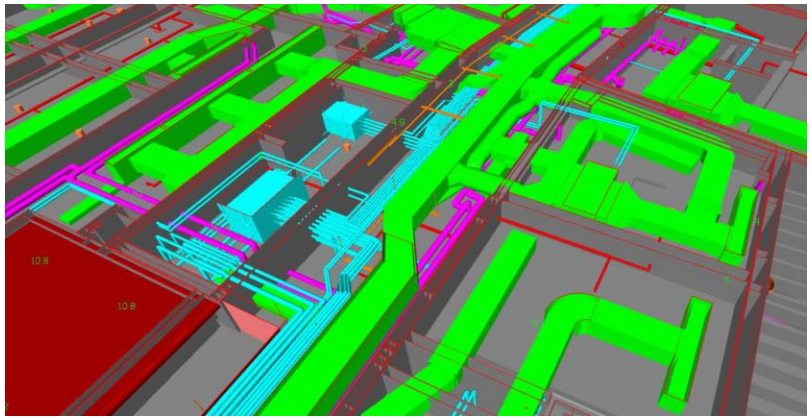
Our Specialties

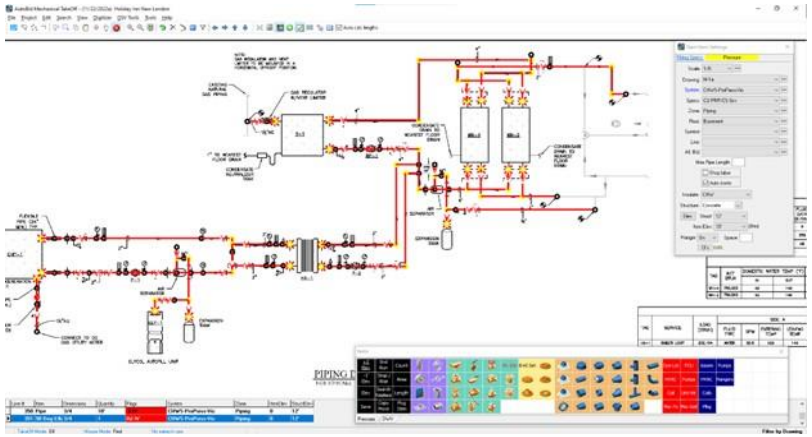
- Boilers
- Building Controls
- Chillers
- Cleanrooms
- Cogeneration
- Compressors
- Design Build HVAC Systems
- Environmental Chambers
- Geothermal Systems
- Lighting
- Microgrid
- Microturbine
- Natural Gas Conversion
- Plan & Spec HVAC
- Process Heating, Cooling and Humidity Control
- Roof Top Unit Change Outs
- Thermal Storage
- VRF: Variable Refrigerant Flow
- VFD: Variable Frequency Drive

Engineering

Controlled Air's engineers are experienced at solving every kind of building environment and facility management challenge. We apply our technical knowledge to your unique set of requirements. Our engineers produce a working plan that gives you quality and flexibility to create the productive working environment you want. Below is an example of our engineering process to help you better understand how our engineering teams develops the best plan for your facility.

- HAP PROGRAM
  - Use ASHRAE Heat Balance load method.
  - Hourly and seasonal scheduling of occupancy, internal heat gains, and fan and thermostat operation.
  - Models one 24-hour cooling design day for each month using ASHRAE recommended design weather data and clear sky solar radiation procedures.
- COORDINATION & 3D MODELING ESTIMATING SOFTWARE
  - Our estimating software provides up-to-date information on the cost of material and labor.
  - Builds historical data to provide a competitive proposal.
  - The model visualization provides a level of clarity and understanding for all involved in our projects.
- LOAD CALCULATIONS & ENERGY ANALYSIS
  - Model shapes, structures, and systems in 3D with parametric accuracy, precision, and ease.
  - Empower multidisciplinary teams with specialty toolsets and a unified project environment





Energy Efficiency

To maximize incentives for HVAC, controls, and lighting, we review buildings for all potential upgrades. We then conduct a full energy study and find the best possible rebates and incentives to help pay for them.

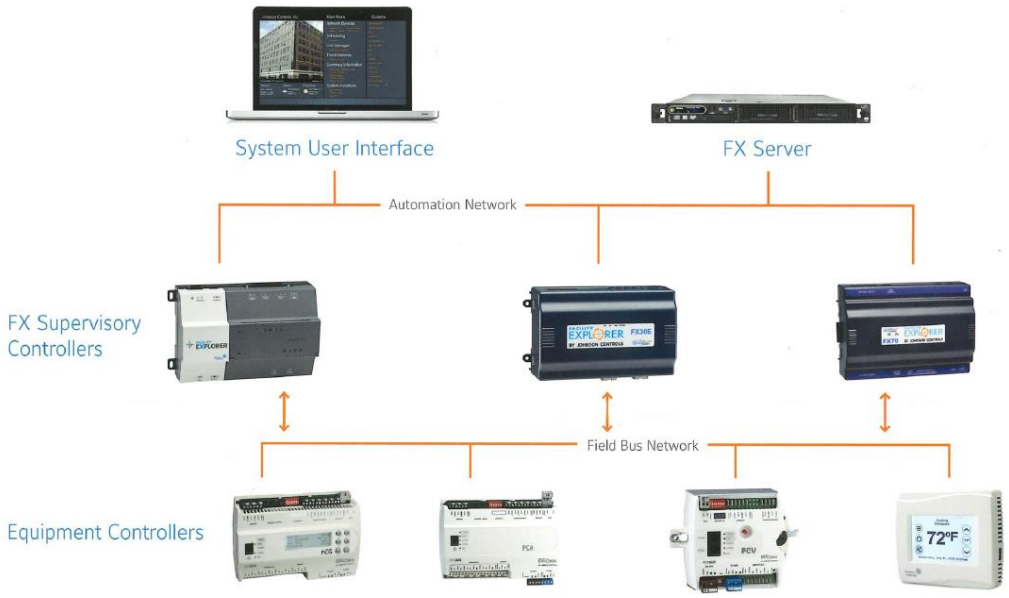
Controlled Air, Inc. uses Carrier's (HAP) "Hourly Analysis Program"; a DOE tested and approved whole building energy simulation software; recognized by ASRHAE, the utility companies, the state and federal authorities as an accepted method for comparing energy saving measures. The HAP program helps create a building baseline that is used for evaluation against energy saving measures.

We can create multiple simulations for comparison to give you the most energy efficient equipment and potential savings. This allows for a determination of ROI and can be submitted for tax, rebate and incentive purposes.

Building Management & Controls

- We are an Authorized Building and Controls Specialist, for Johnson Controls for all of Connecticut and part of Massachusetts. Johnson Controls is a leading full-line service provider of mechanical equipment as well as systems that control heating, ventilating, air conditioning (HVAC), lighting, security and fire management in non-residential buildings. The company is a world leader in integrated facility management for Fortune 500 companies, managing more than one billion square feet worldwide.
- Improving energy efficiency is the first and most important step toward achieving sustainability in buildings and organizations. Energy efficiency helps control rising energy costs, reduces environmental footprints, and increases the value and competitiveness of buildings. Working with Johnson Controls, Controlled Air, Inc. can provide the leading technology and equipment to create the best possible solutions for every application.
- Controlled Air, Inc. can help you maximize energy dollars through advanced Energy Management systems. Computerized tools are programmed to your specifications to monitor controls, achieve better energy efficiency and to optimize the performance of your system.

Johnson Controls



Controlled Air INC. HVAC, Building Controls & Energy Systems YANMAR GROUP

YANMAR strive to provide sustainable solutions for needs which are essential to human life. We focus on the challenges our customers face in food production and harnessing power, thereby enriching people's lives for all our tomorrows.

In 1992, YANMAR VRF Division established, meeting the need for energy efficient and environmentally friendly VRF products.
In 2010, First US model of 10kW CHP unit (Natural Gas) launched

YANMAR Energy Systems has created energy-responsible systems, including the heat pump, micro-combined heat and power (mCHP), power generation and drive systems. These systems work independently or can be integrated with each other and your current systems, creating even greater efficiency and cost savings.

Variable Refrigerant Flow Systems: Switching from electric driven systems to YANMAR's high efficiency natural gas-powered Variable Refrigerant Flow (VRF) systems reduces electrical load by approximately 90%. These units effectively lower peak demand for electrical power during the summer air conditioning season.

YANMAR

VRF TECHNOLOGY

GAS HEAT PUMP

RNG &
NATURAL GAS POWERED

AIR CONDITIONING

LOW CARBON FOOTPRINT
RELIABLE
LOW MAINTENANCE

COGENERATION

MICRO CHP

COMBINED

HEAT & POWER SYSTEMS

ENVIRONMENTALLY RESPONSIBLE
GENERATES ON-SITE ELECTRICITY
VERSATILE, RELIABLE, & RESILIENT

REDUCE OPERATIONAL COST BY **30-70%**

REDUCE ELECTRICAL CONSUMPTION BY **90%**

ENGINE DRIVEN TECHNOLOGY

QUIET OPERATION **54-58 DB**

ENERGY SOLUTIONS

VRF HEAT PUMP & HEAT RECOVERY

HYDRO BOX AVAILABLE

POWER CONNECTION SINGLE PHASE **208-240V**

VERSATILE FOR ALL ENVIRONMENTS

VERSATILE SOLUTIONS FOR ALL ENVIRONMENTS | COMMERCIAL | MULTI-FAMILY | MULTI-STORY MODULAR SOCIAL HOUSING | MULTIPLEX/AQUATIC CENTRES | GOVERNMENT | MUNICIPAL | HOSPITALS | SCHOOLS | HOTELS

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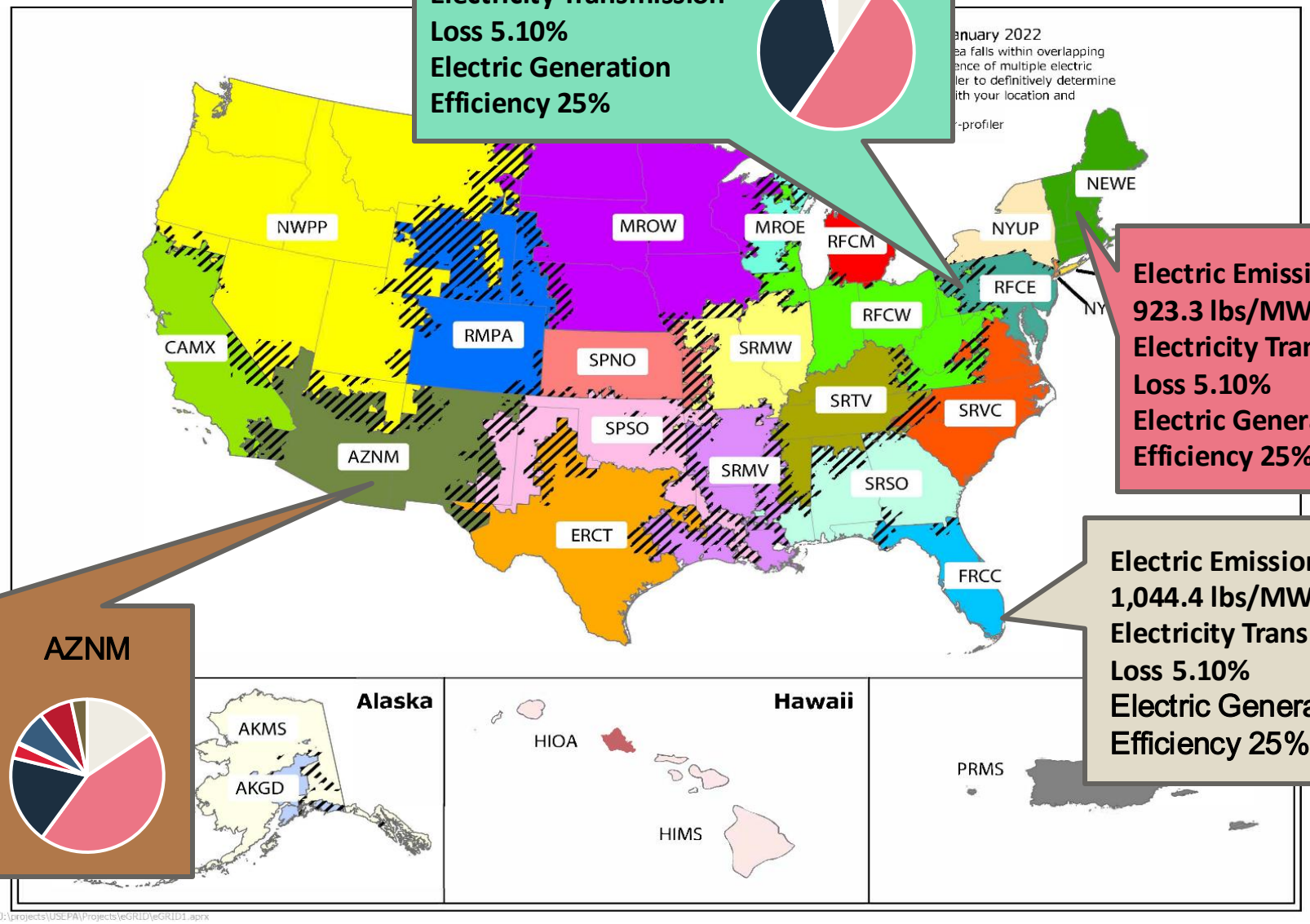
Debunking Myths: Carbon Reduction with Electrification

Debunking Myths: Carbon Reduction with Electrification

- Myth: Electricity is Cleaner than Natural Gas
- Fact: Most electrical grids are not cleaner than Natural Gas
  - Electricity doesn't automatically equate to de-carbonization. In the U.S., the primary sources for electricity generation are still natural gas and coal, which contribute significantly to carbon emissions.
- Myth: Electrification automatically decreases overall carbon emissions.
- Fact: While electric heating systems produce zero emissions at the point of use, the source of the electricity can significantly increase emissions.
  - Considering generation and transmission losses, delivering one unit of electricity to the end user can require up to three units of source energy, making fossil-fuel-generated electricity less efficient and potentially more carbon-intensive than direct use of natural gas.
- Myth: America can handle the transition to full electrification with ease.
- Fact: The U.S. power grid will not be ready for full electrification within the next several decades.
  - Current power demands are rising, and transitioning to full electrification would add further strain. In regions where grids are already under pressure, increased demand from electric heating and electric vehicles requires new power plants and significant grid upgrades.

eGrid 2022 Data

- Coal
- Oil
- Gas
- Other Fossil
- Nuclear
- Hydro
- Biomass
- Wind
- Solar
- Geo- thermal

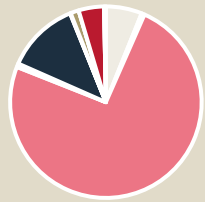


Electric Emissions (CO2) RFCE
1,278.7 lbs/MWh
Electricity Transmission
Loss 5.10%
Electric Generation
Efficiency 25%

Electric Emissions (CO2) NEWE
923.3 lbs/MWh
Electricity Transmission
Loss 5.10%
Electric Generation
Efficiency 25%

Electric Emissions (CO2) AZNM
1,205 lbs/MWh
Electricity Transmission
Loss 5.10%
Electric Generation
Efficiency 25%

Electric Emissions (CO2) FRCC
1,044.4 lbs/MWh
Electricity Transmission
Loss 5.10%
Electric Generation
Efficiency 25%



1. Subregion Output Emission Rates (eGRID2022)

eGRID subregion acronym	eGRID subregion name	Total output emission rates lb/MWh							Non-baseload output emission rates lb/MWh							Grid Gross Loss (%)
		CO_2	CH_4	N_2O	CO_2e	Annual NO_X	Ozone Season NO_X	SO_2	CO_2	CH_4	N_2O	CO_2e	Annual NO_X	Ozone Season NO_X	SO_2	
AKGD	ASCC Alaska Grid	1,052.1	0.088	0.012	1,057.8	5.1	5.4	0.423	1,224.5	0.123	0.017	1,232.5	7.0	7.6	0.583	5.0%
AKMS	ASCC Miscellaneous	495.8	0.023	0.004	497.6	7.9	7.3	0.680	1,587.9	0.069	0.012	1,593.3	25.4	24.6	2.185	5.0%
AZNM	WECC Southwest	776.0	0.051	0.007	779.4	0.4	0.4	0.121	**1,205.2**	0.065	0.009	1,209.5	0.7	0.7	0.162	**5.1%**
CAMX	WECC California	497.4	0.030	0.004	499.3	0.5	0.4	0.030	1,055.0	0.049	0.006	1,058.0	0.8	0.7	0.055	5.1%
ERCT	ERCOT All	771.1	0.049	0.007	774.3	0.5	0.5	0.407	1,194.9	0.067	0.009	1,199.2	0.9	0.9	0.665	5.1%
FRCC	FRCC All	813.8	0.048	0.006	816.9	0.3	0.3	0.142	**1,044.4**	0.056	0.007	1,048.0	0.4	0.4	0.208	**5.1%**
HIMS	HICC Miscellaneous	1,155.5	0.124	0.019	1,163.1	7.2	7.3	3.069	1,619.2	0.157	0.025	1,629.6	11.4	11.9	4.074	5.4%
HIOA	HICC Oahu	1,575.4	0.163	0.025	1,586.9	3.9	3.7	6.353	1,810.3	0.177	0.028	1,822.9	4.4	4.2	7.330	5.4%
MROE	MRO East	1,479.6	0.133	0.019	1,488.7	1.0	1.0	0.306	1,672.9	0.147	0.021	1,682.8	1.1	1.2	0.334	5.1%
MROW	MRO West	936.5	0.102	0.015	943.4	0.8	0.9	0.907	1,794.7	0.183	0.026	1,807.0	1.6	1.6	1.640	5.1%
NEWE	NPCC New England	536.4	0.063	0.008	540.5	0.3	0.3	0.122	**923.3**	0.073	0.010	928.1	0.5	0.3	0.249	**5.1%**
NWPP	WECC Northwest	602.1	0.056	0.008	605.9	0.5	0.5	0.318	1,515.7	0.134	0.019	1,524.7	1.5	1.5	0.790	5.1%
NYCW	NPCC NYC/Westchester	885.2	0.023	0.003	886.6	0.2	0.2	0.028	971.8	0.021	0.002	973.0	0.3	0.3	0.021	5.1%
NYLI	NPCC Long Island	1,200.7	0.135	0.018	1,209.3	0.9	0.9	0.474	1,316.7	0.039	0.005	1,319.1	0.9	0.8	0.654	5.1%
NYUP	NPCC Upstate NY	274.6	0.015	0.002	275.4	0.1	0.1	0.043	920.1	0.043	0.005	922.5	0.5	0.3	0.189	5.1%
PRMS	Puerto Rico Miscellaneous	1,593.5	0.087	0.014	1,599.9	3.1	3.1	4.262	1,670.9	0.074	0.013	1,676.7	3.5	3.5	5.578	0.0%
RFCE	RFC East	657.4	0.045	0.006	660.3	0.3	0.2	0.302	**1,278.7**	0.097	0.013	1,285.1	0.7	0.6	0.773	**5.1%**
RFCM	RFC Michigan	1,216.4	0.116	0.016	1,224.2	0.6	0.6	0.931	1,597.3	0.149	0.021	1,607.4	0.9	0.8	1.413	5.1%
RFCW	RFC West	1,000.1	0.087	0.012	1,005.9	0.5	0.4	0.620	1,843.6	0.178	0.026	1,855.7	1.1	0.9	1.180	5.1%
RMPA	WECC Rockies	1,124.9	0.101	0.014	1,131.7	0.6	0.6	0.348	1,676.4	0.129	0.018	1,685.1	0.9	0.9	0.430	5.1%
SPNO	SPP North	952.6	0.100	0.014	959.4	0.5	0.6	0.160	1,943.0	0.198	0.029	1,956.5	1.2	1.2	0.325	5.1%
SPSO	SPP South	970.4	0.072	0.010	975.3	0.8	0.8	0.862	1,528.2	0.105	0.015	1,535.2	1.3	1.3	1.291	5.1%
SRMV	SERC Mississippi Valley	801.0	0.040	0.006	803.7	0.5	0.5	0.602	1,220.7	0.073	0.010	1,225.6	0.9	0.9	1.407	5.1%
SRMW	SERC Midwest	1,369.9	0.151	0.022	1,380.2	1.0	0.7	2.410	1,808.6	0.186	0.027	1,821.2	1.4	1.1	3.244	5.1%
SRSO	SERC South	893.3	0.064	0.009	897.7	0.4	0.4	0.151	1,354.8	0.092	0.013	1,361.1	0.8	0.6	0.309	5.1%
SRTV	SERC Tennessee Valley	933.1	0.082	0.012	938.6	0.4	0.4	0.537	1,671.0	0.152	0.022	1,681.3	0.7	0.6	0.968	5.1%
SRVC	SERC Virginia/Carolina	623.0	0.047	0.007	625.9	0.3	0.3	0.157	1,308.8	0.099	0.014	1,315.1	0.7	0.7	0.351	5.1%
U.S.		**823.1**	**0.066**	**0.009**	**827.5**	**0.5**	**0.5**	**0.473**	**1,405.3**	**0.107**	**0.015**	**1,412.5**	**1.0**	**0.9**	**0.838**	**5.1%**

USA Generation Chart Subregion Resource Mix (eGRID2022)

eGRID subregion acronym	eGRID subregion name	Nameplate Capacity (MW)	Net Generation (MWh)	Generation Resource Mix (percent)*										
				Coal	Oil	Gas	Other Fossil	Nuclear	Hydro	Biomass	Wind	Solar	Geo-thermal	Other unknown/ purchased fuel
AKGD	ASCC Alaska Grid	2,170	5,016,815	14.5%	8.8%	62.3%	0.0%	0.0%	11.5%	0.8%	2.1%	0.0%	0.0%	0.0%
AKMS	ASCC Miscellaneous	920	1,677,313	0.0%	24.1%	6.3%	0.0%	0.0%	67.7%	0.0%	2.0%	0.0%	0.0%	0.0%
AZNM	WECC Southwest	52,133	170,369,549	**15.7%**	**0.0%**	**44.3%**	**0.0%**	**18.7%**	**3.1%**	**0.3%**	**7.4%**	**7.0%**	**3.4%**	**0.0%**
CAMX	WECC California	93,348	209,353,986	2.7%	0.1%	46.2%	0.8%	8.4%	7.9%	2.4%	7.2%	20.4%	3.9%	0.0%
ERCT	ERCOT All	139,101	458,259,386	15.5%	0.1%	46.8%	0.4%	9.1%	0.1%	0.2%	23.0%	4.7%	0.0%	0.1%
FRCC	FRCC All	70,810	250,233,811	**6.1%**	**0.5%**	**74.4%**	**0.6%**	**12.3%**	**0.1%**	**1.4%**	**0.0%**	**4.3%**	**0.0%**	**0.3%**
HIMS	HICC Miscellaneous	1,045	2,708,213	0.0%	64.4%	0.0%	0.0%	0.0%	4.1%	3.6%	12.6%	5.5%	7.7%	2.1%
HIOA	HICC Oahu	2,298	6,595,979	9.8%	74.5%	0.0%	3.1%	0.0%	0.0%	2.7%	3.8%	6.1%	0.0%	0.0%
MROE	MRO East	8,453	22,864,489	45.8%	0.7%	37.8%	0.1%	0.0%	4.8%	3.7%	3.8%	3.2%	0.0%	0.0%
MROW	MRO West	76,840	251,623,837	38.0%	0.1%	8.3%	0.1%	8.1%	3.9%	0.7%	39.8%	1.0%	0.0%	0.1%
NEWE	NPCC New England	38,880	105,455,877	**0.3%**	**1.8%**	**52.7%**	**1.6%**	**26.0%**	**5.9%**	**4.5%**	**3.8%**	**3.3%**	**0.0%**	**0.1%**
NWPP	WECC Northwest	80,186	290,045,161	18.2%	0.2%	18.9%	0.2%	3.4%	44.0%	1.0%	10.8%	2.5%	0.6%	0.1%
NYCW	NPCC NYC/Westchester	12,790	32,721,381	0.0%	2.3%	96.6%	0.6%	0.0%	0.0%	0.5%	0.0%	0.1%	0.0%	0.0%
NYLI	NPCC Long Island	5,885	10,828,139	0.0%	6.4%	82.7%	4.8%	0.0%	0.0%	3.9%	0.0%	2.3%	0.0%	0.0%
NYUP	NPCC Upstate NY	26,053	87,177,697	0.0%	0.5%	29.2%	0.3%	30.8%	30.9%	1.5%	5.2%	1.6%	0.0%	0.0%
PRMS	Puerto Rico Miscellaneous	6,405	17,762,020	16.7%	48.6%	32.3%	0.0%	0.0%	0.0%	0.0%	0.9%	1.6%	0.0%	0.0%
RFCE	RFC East	78,447	289,058,252	**8.8%**	**0.2%**	**50.2%**	**0.7%**	**36.2%**	**1.1%**	**0.9%**	**1.0%**	**0.9%**	**0.0%**	**0.0%**
RFCM	RFC Michigan	31,060	93,807,524	36.6%	1.6%	38.5%	1.4%	10.0%	0.0%	1.6%	9.4%	0.9%	0.0%	0.0%
RFCW	RFC West	140,293	535,522,392	31.4%	0.3%	32.0%	0.7%	27.6%	1.0%	0.4%	6.0%	0.5%	0.0%	0.1%
RMPA	WECC Rockies	23,744	67,125,368	36.6%	0.0%	23.6%	0.0%	0.0%	8.4%	0.2%	27.5%	3.5%	0.0%	0.1%
SPNO	SPP North	26,861	78,559,613	37.1%	0.0%	10.9%	0.0%	11.4%	0.2%	0.1%	40.3%	0.1%	0.0%	0.0%
SPSO	SPP South	57,781	155,729,281	23.4%	1.2%	38.8%	0.1%	0.0%	3.2%	1.4%	31.4%	0.4%	0.0%	0.1%
SRMV	SERC Mississippi Valley	47,214	183,054,493	10.5%	0.8%	63.4%	1.2%	21.4%	1.2%	1.0%	0.0%	0.5%	0.0%	0.2%
SRMW	SERC Midwest	33,720	118,737,335	59.1%	0.1%	11.8%	0.1%	15.2%	1.3%	0.1%	10.9%	1.2%	0.0%	0.2%
SRSO	SERC South	72,050	257,187,544	17.7%	0.2%	53.8%	0.0%	18.3%	2.9%	3.9%	0.0%	3.2%	0.0%	0.0%
SRTV	SERC Tennessee Valley	57,331	214,916,301	29.2%	0.1%	30.4%	0.0%	30.2%	8.7%	0.7%	0.0%	0.7%	0.0%	0.0%
SRVC	SERC Virginia/Carolina	95,391	323,748,776	11.0%	0.3%	40.2%	0.2%	38.7%	1.2%	2.3%	0.5%	5.5%	0.0%	0.1%
U.S.		**1,281,209**	**4,240,140,533**	**19.7%**	**0.7%**	**39.8%**	**0.5%**	**18.2%**	**5.9%**	**1.2%**	**10.2%**	**3.4%**	**0.4%**	**0.1%**

*percentages may not sum to 100 due to rounding

Technical Specifications of Gas Heat Pump

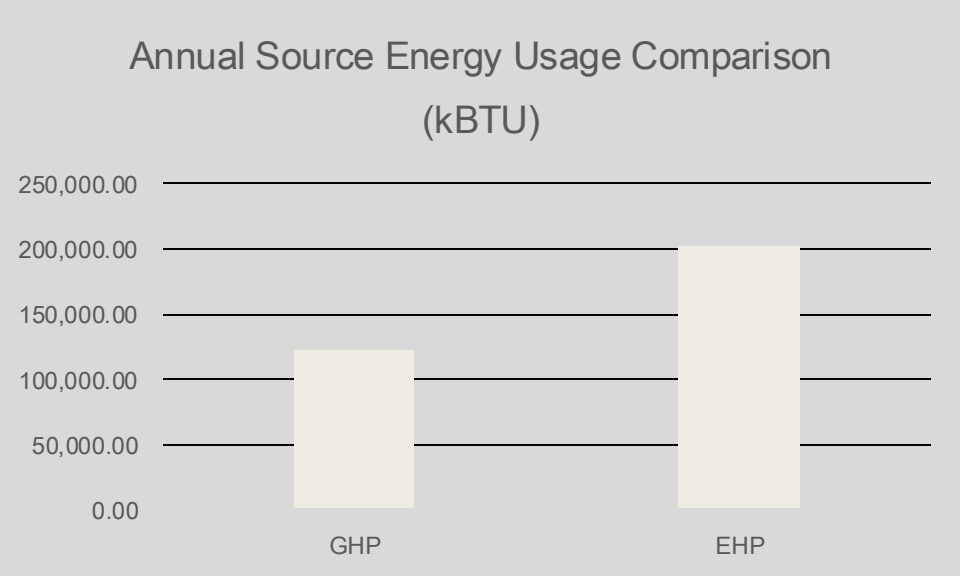
GHP System Data	
Cooling Output	5 Ton
Heating Output	68,240 BTU/h
Cooling Gas Input	.51 ccf/h
Heating Gas Input	.50 ccf/h
Efficiency	1.13 COP – cooling 1.3 COP - heating
Emission Rate	10.34 lbs/ccf/h

Technical Specifications of Electric Heat Pump

EHP System Data	
Cooling Output	5 Ton
Heating Output	60,000 BTU/h
Cooling Electric Input	0.08 W/BTU/h
Heating Electric Input	.12 W/BTU/h
Efficiency	3.5 COP – cooling 2.4 COP - heating
Emission Rate	Per Source Emission

Energy Usage (Boston, Massachusetts)

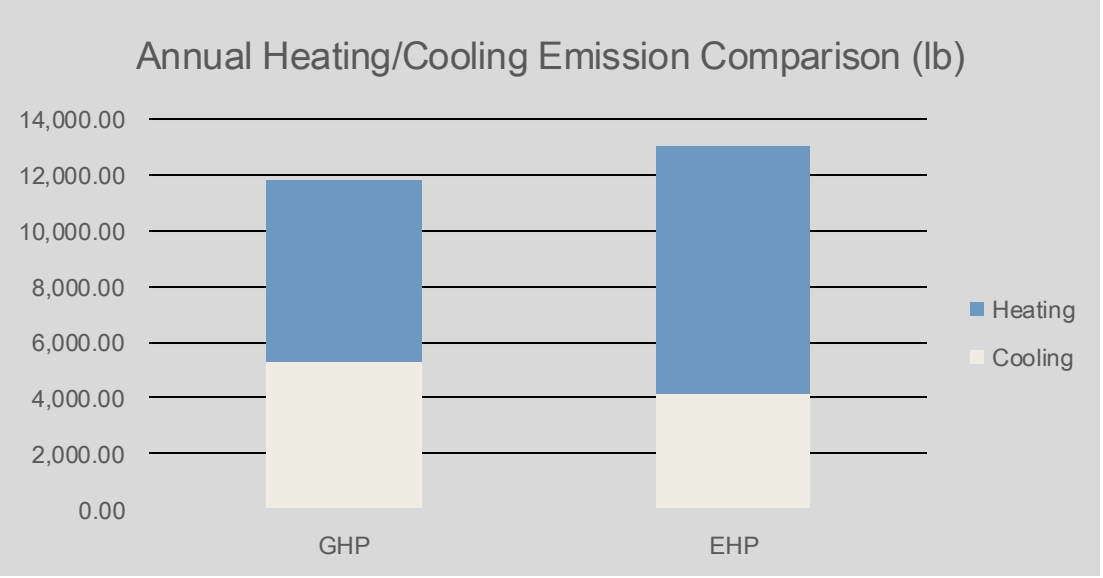
	GHP	EHP	Annual Energy Savings
	Source Energy (kBTU)	Source Energy (kBTU)	Source Energy (kBTU)
Cooling	54,894.15	64,910.25	10,016.11
Heating	68,268.53	137,890.66	69,622.13
Total	123,162.68	202,800.91	**79,638.24**



CO_2 Emissions (Boston, Massachusetts)

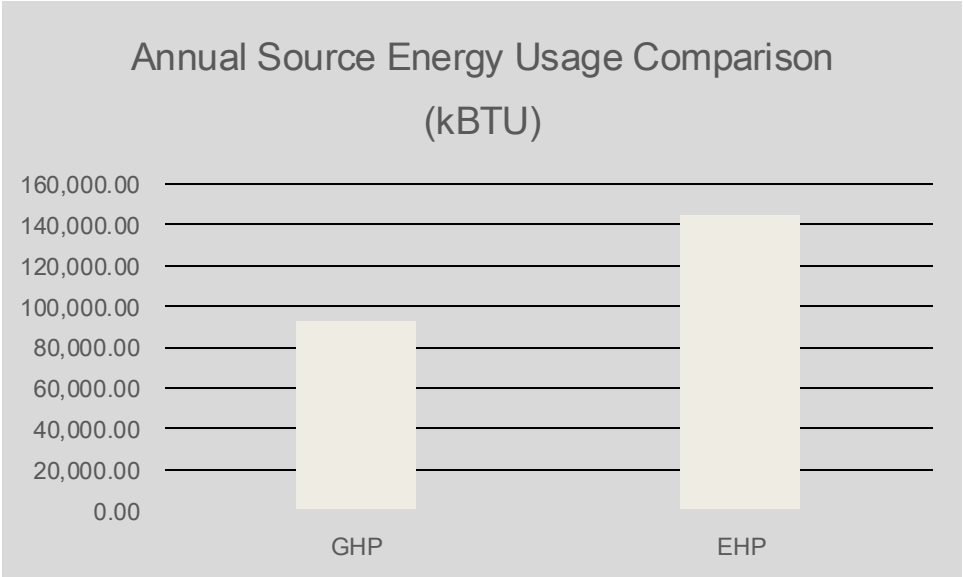
	GHP			EHP			Annual GHP Emission Savings (lbs)
	Gas Emission (lbs)	Electric Emission (lbs)	Total Emission (lbs)	Gas Emission (lbs)	Electric Emission (lbs)	Total Emission (lbs)	
Cooling	4,728.05	534.31	5,262.36	0.00	4,167.46	4,167.46	-1,094.91
Heating	5,851.55	683.62	6,535.17	0.00	8,853.10	8,853.10	2,317.93
Total	10,579.60	1,217.93	11,797.53	0.00	13,020.55	13,020.55	**1,223.02**

Non-baseload output emission rates (CO2): 923.3 lbs/MWh



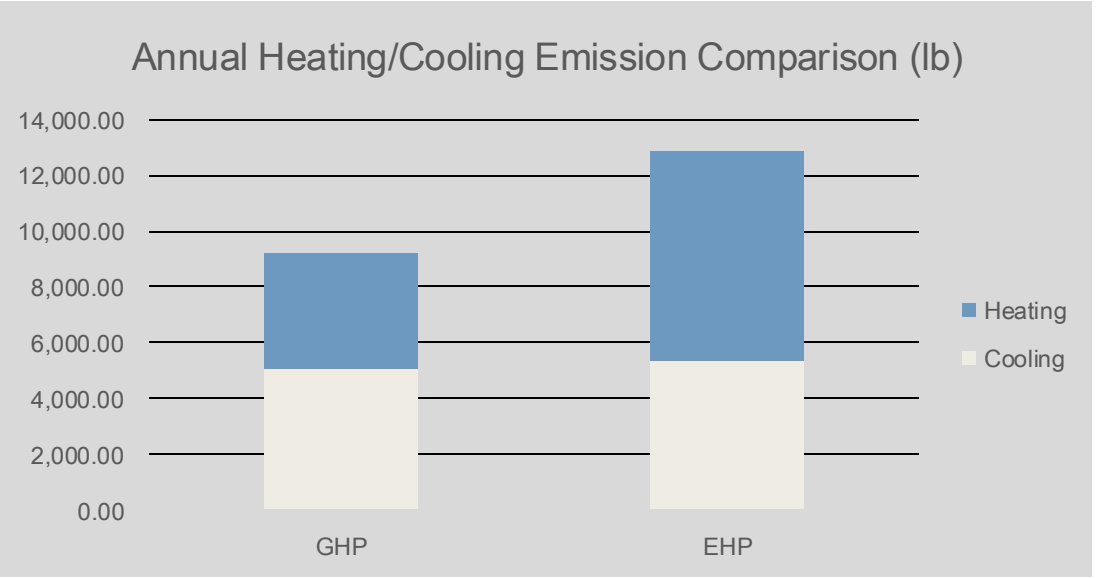
Energy Usage (Madison, New Jersey)

	GHP	EHP	Annual Energy Savings
	Source Energy (kBTU)	Source Energy (kBTU)	Source Energy (kBTU)
Cooling	50,932.71	60,226.01	9,293.29
Heating	41,690.71	84,208.04	42,517.33
Total	92,623.42	144,434.05	**51,810.63**



CO_2 Emissions (Madison, New Jersey)

	GHP			EHP			Annual GHP Emission Savings (lbs)
	Gas Emission (lbs)	Electric Emission (lbs)	Total Emission (lbs)	Gas Emission (lbs)	Electric Emission (lbs)	Total Emission (lbs)	
Cooling	4,386.85	686.55	5,073.40	0.00	5,354.83	5,354.83	281.44
Heating	3,573.47	578.14	4,151.61	0.00	7,487.16	7,487.16	3,335.55
Total	7,960.32	1,264.69	9,225.01	0.00	12,841.99	12,841.99	**3,616.98**



Non-baseload output emission rates (CO2): 1,278.7 lbs/MWh

Combined Heat & Power 35kW

CHP

Combined Heat & Power

Using gas engine to provide electric power and hot water

Technical Specifications of Combined Heat and Power

CHP System Data	
Manufacturer	Yanmar
Model Number	CP35D2
Power	35 kW
Heat Recovered	200.16 MBH
Heat Input	3.58 ccf/h
CHP Emission Rate	1,232.38 lb/MWh

Calculation Assumptions

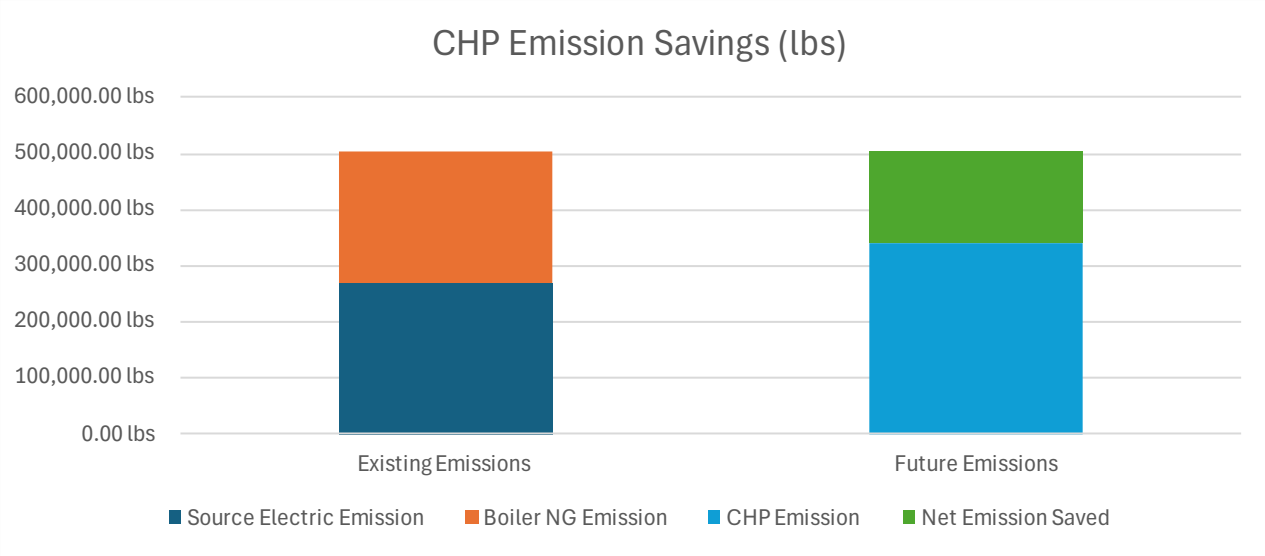
Assumptions	
Load	100%
Boiler Efficiency	80%
Uptime	90%
HHV of 1ccf of NG	102.80 kBTU
Boiler Emission	12.30 lbs/ccf
Electric Emission Rate	Per Source Emission

CHP System Performance

System Performance/Annual	
Uptime Hours	7,884
Total Electric Generation	275,940 kWh
Total Heat Recovered	1,578,061 kBTU
Total NG Saved (Boiler Offset)	19,188 ccf
Total CHP Thermal Input	2,897,843 kBTU
Total CHP Gas Input	28,189 ccf

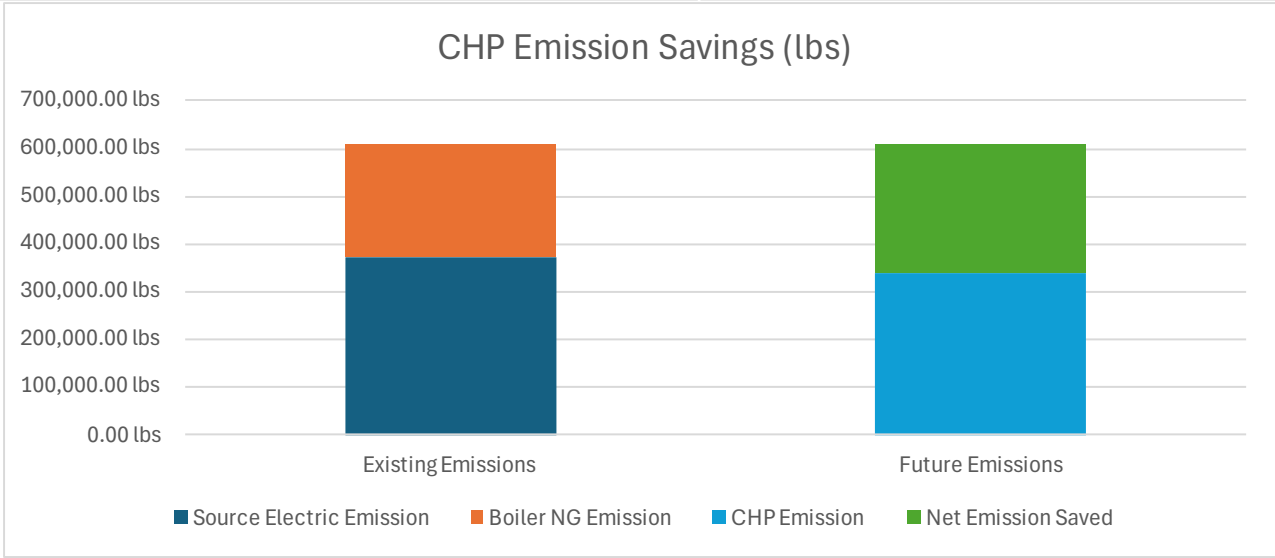
CO_2 Emissions for Boston, Massachusetts

Annual Emissions	
CHP Emissions	-340,064.11 lbs
Source Electric Emission Saved	268,481.77 lbs
Boiler NG Emission Saved	236,018.43 lbs
Net Emission Saved	**164,436.09 lbs**



CO_2 Emissions for Madison, New Jersey

Annual Emissions	
CHP Emissions	-340,064.11 lbs
Source Electric Emission Saved	371,806.62 lbs
Boiler NG Emission Saved	236,018.43 lbs
Net Emission Saved	**267,760.94 lbs**



Summary: The Carbon Advantage of Gas Heat Pumps and CHP Units

- Efficient Energy Utilization:
  - Gas Heat Pumps: Utilize natural gas more efficiently, their equivalent efficiency rating of 140% for heating as compared to a normally 95% efficient condensing boiler of furnace .
  - Combined Heat and Power (CHP) Units: Generate electricity and useful heat simultaneously, achieving efficiency levels of up to 80-90%, significantly higher than the average power plant.
- Reduced Transmission Losses:
  - Deliver energy directly to the point of use, avoiding the significant transmission and distribution losses inherent in the electrical grid.
- Reduce Emissions:
  - Beyond the low carbon emissions, there are other environmental impacts such as particulate matter, NOx emissions, and water usage. Gas Heat Pumps and CHP units often have a lower overall environmental footprint.
- Grid Resilience:
  - Decrease the load on the electrical grid, helping to prevent overloading and reducing the need for extensive grid upgrades and new power plant constructions.
- Sustainable Transition:
  - Provide a viable, lower-carbon alternative during the transition to renewable energy sources, supporting a more sustainable and resilient energy infrastructure.
- Lifecycle Emissions:
  - Also considering the entire lifecycle emissions of a system, from fuel extraction and processing to end-use. Gas Heat Pumps and CHP units tend to have lower lifecycle emissions compared to electric systems relying on fossil-fuel-generated electricity.

Conclusion

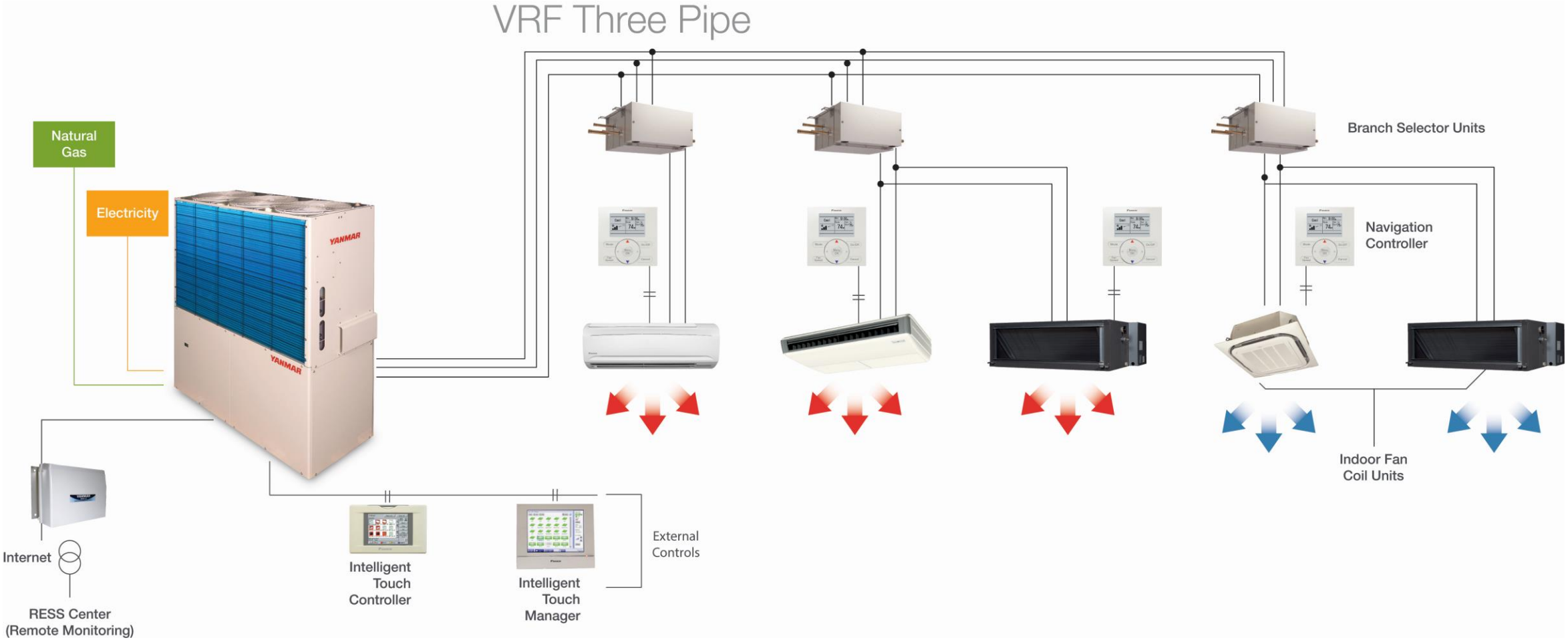
- Gas Heat Pumps and Combined Heat and Power units offer a sustainable solution for reducing carbon emissions, enhancing efficiency, and maintaining grid stability
- Embracing the use of these high-efficiency gas products paves the way towards a cleaner and more sustainable energy future
- Acknowledging we need these products to allow natural gas to perform its vital role in the energy transition process.
- Gas Heat Pumps and Combined Heat and Power units provide a cost-effective alternative to high energy costs while still reducing our carbon footprint

Gas Heat Pumps (GHP)

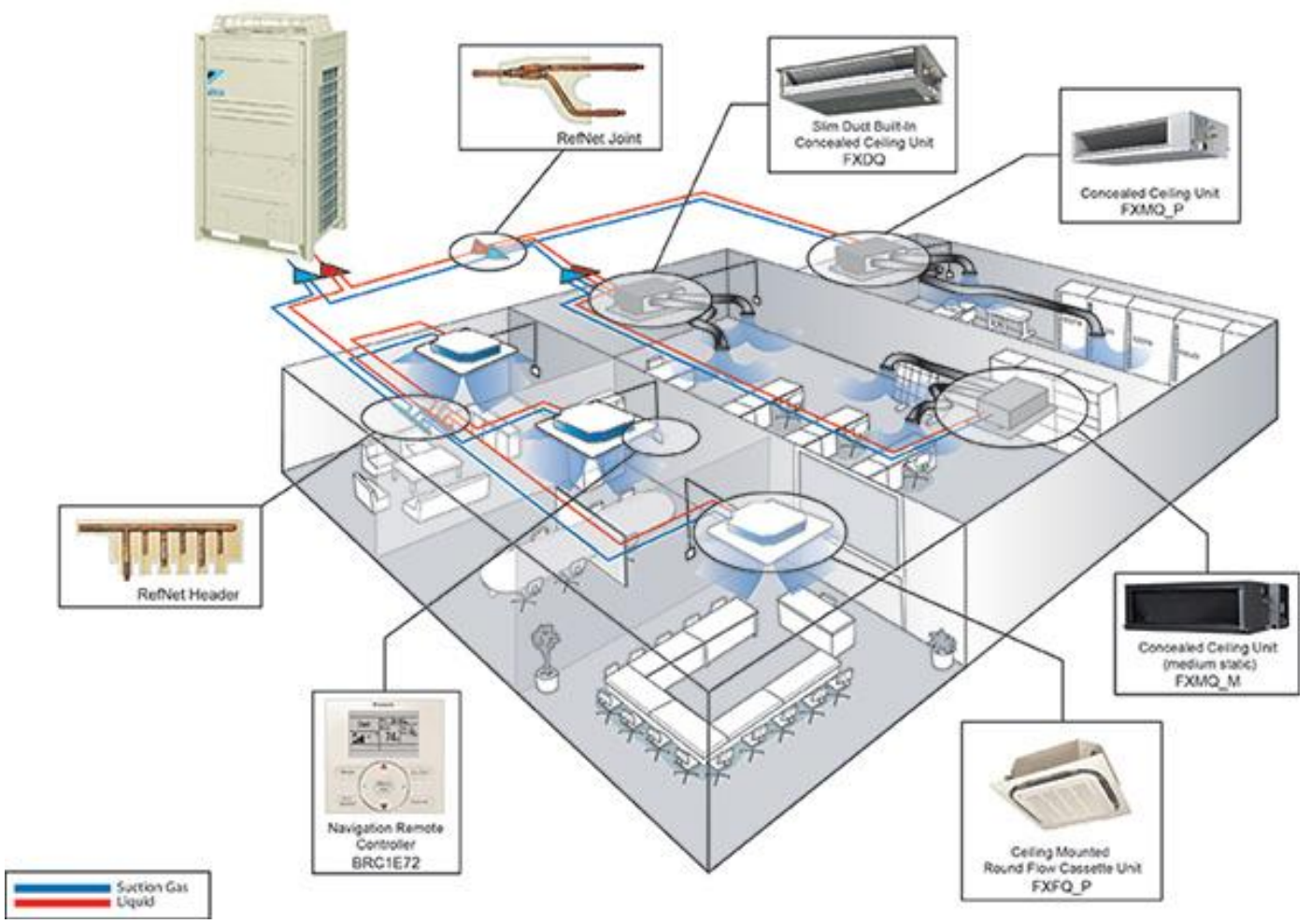
YANMAR GHP: What is Variable Refrigerant Flow (VRF) Technology?

- VRF (Variable Refrigerant Flow) is a HVAC technology that uses refrigerant as the cooling and heating medium. The refrigerant is conditioned by an outdoor condensing unit and circulated within the building to multiple indoor fan coil units where heat or cool air is distributed. Unlike traditional HVAC, VRF systems can be configured in ducted or non-ducted applications, so indoor fan coil units may be installed in any space. Another VRF advantage is the ability for each zone to be controlled by its own thermostat. This enables different zones to have varying temperatures at the same time, and for heating and cooling to occur in different zones simultaneously.
  - **Key benefits VRF systems include:**
    - Energy Efficiency
    - Economic Savings
    - Environmentally Responsible
    - Zoned Comfort
    - Design Flexibility
    - Quiet
    - Less Temperature Fluctuation

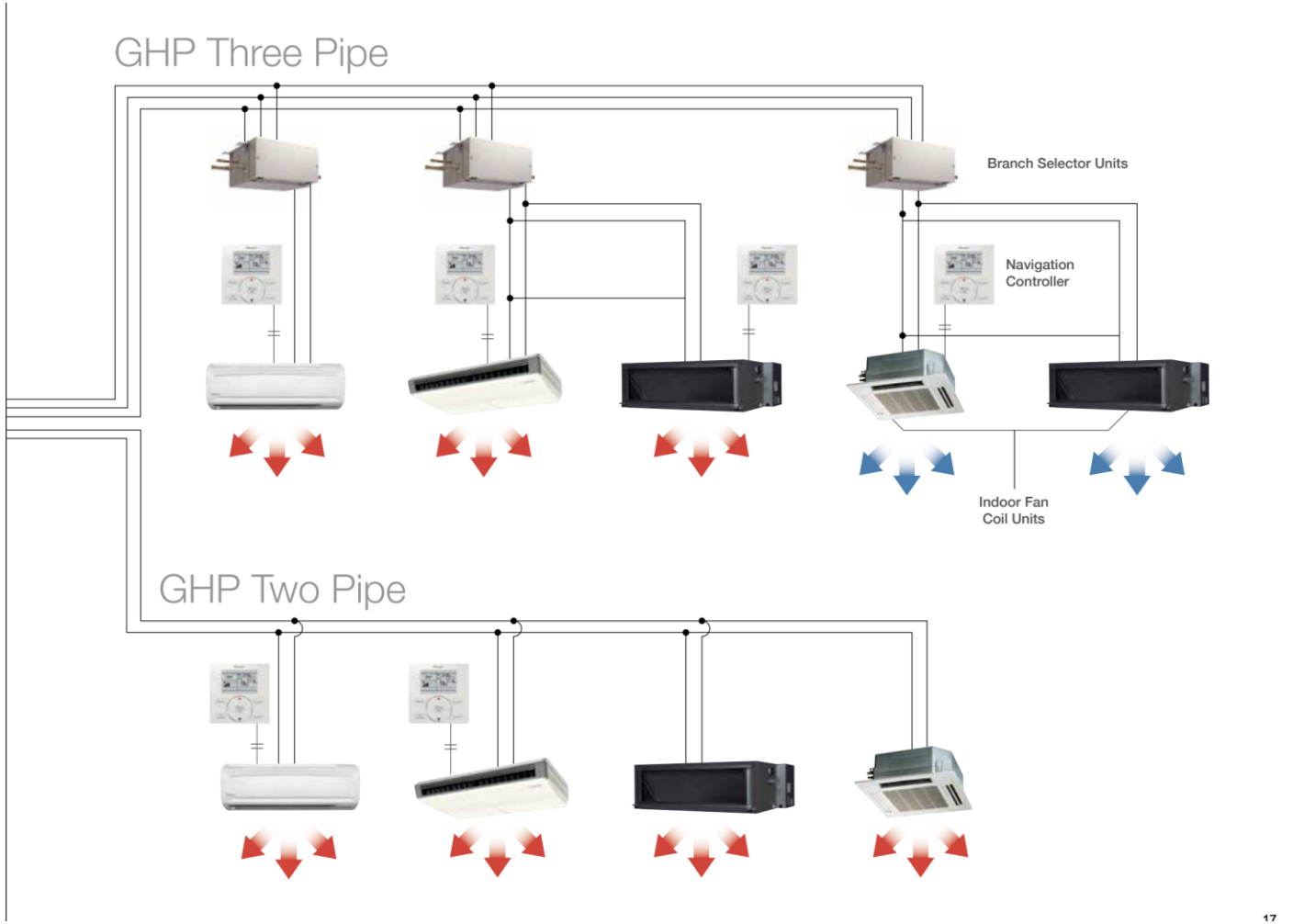
YANMAR GHP


VRF Three Pipe
Natural Gas
Electricity
YANMAR
YANMAR
Branch Selector Units
Navigation Controller
Indoor Fan Coil Units
Internet
RESS Center (Remote Monitoring)
Intelligent Touch Controller
Intelligent Touch Manager
External Controls

VRF/VRV Technology



GHP 3-PIPE VERSUS 2-PIPE SYSTEM



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YANMAR GHP with VRF Technology

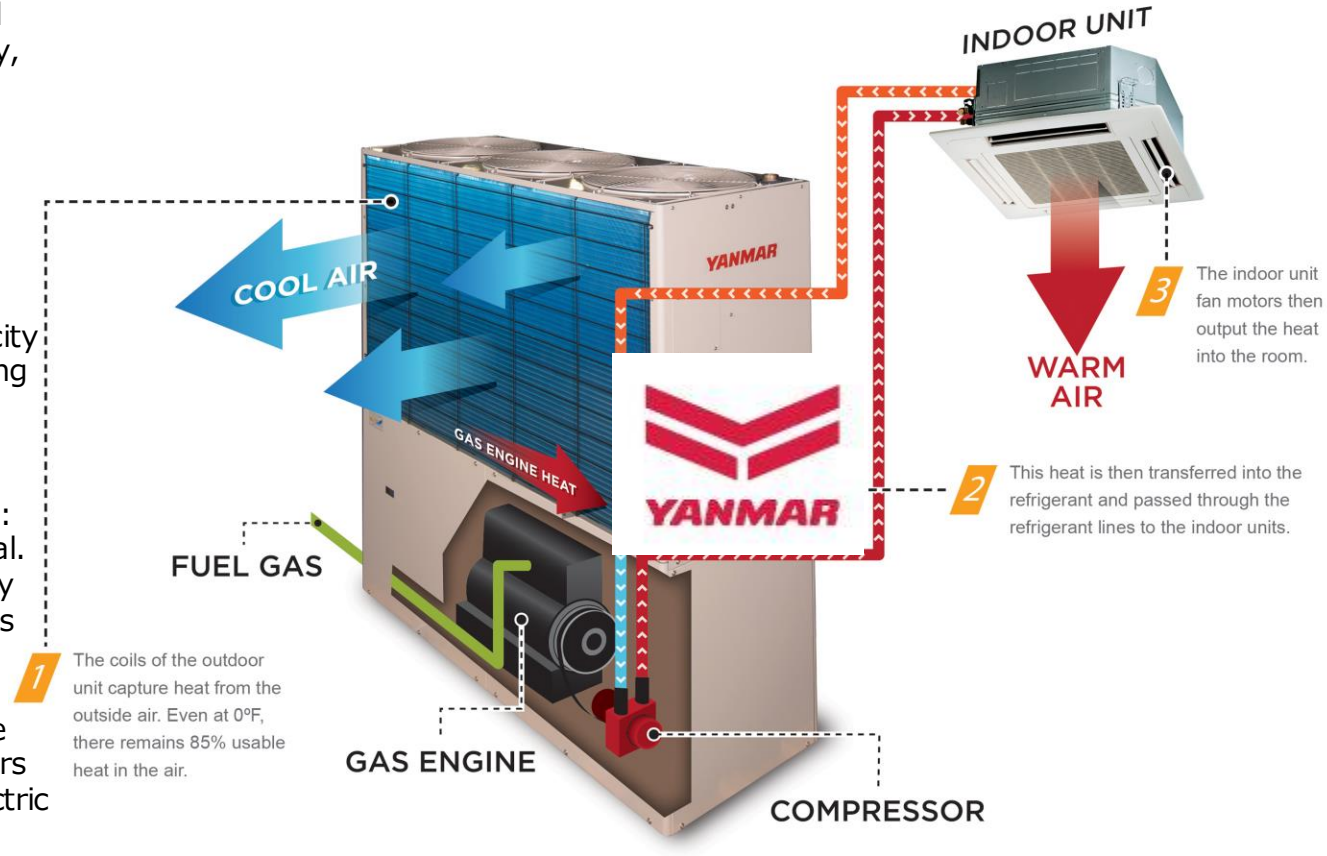
- YANMAR's Variable Refrigerant Flow (VRF) natural gas heat pump systems provide high efficiency heating and cooling for commercial buildings. By using natural gas and reversible air source technology, these world-class engines deliver low running costs, reduced CO2 emissions and use minimal electricity.

- Key benefits to YANMAR's VRF systems include:

  - Energy Efficiency: By utilizing a highly efficient natural gas powered variable speed engine to drive dual scroll compressors, the YANMAR VRF system can reduce electricity usage by up to 90% compared to traditional air conditioning systems.

  - Environmental Benefits: Natural gas as an energy source produces significantly lower amounts of harmful emissions: 80% less NOx, 100% less SOx and 35% less CO2 than coal. By utilizing natural gas, YANMAR's VRF technology not only helps preserve precious energy resources, but also reduces harmful emissions.

  - Economic Savings: With lower operating and infrastructure costs and greater efficiency, the YANMAR VRF system offers substantially lower system lifecycle costs compared to electric systems on the market today. In fact, our VRF system reduces overall running costs by 30-70% depending on local utility costs.



YANMAR GHP: HEATING CYCLE

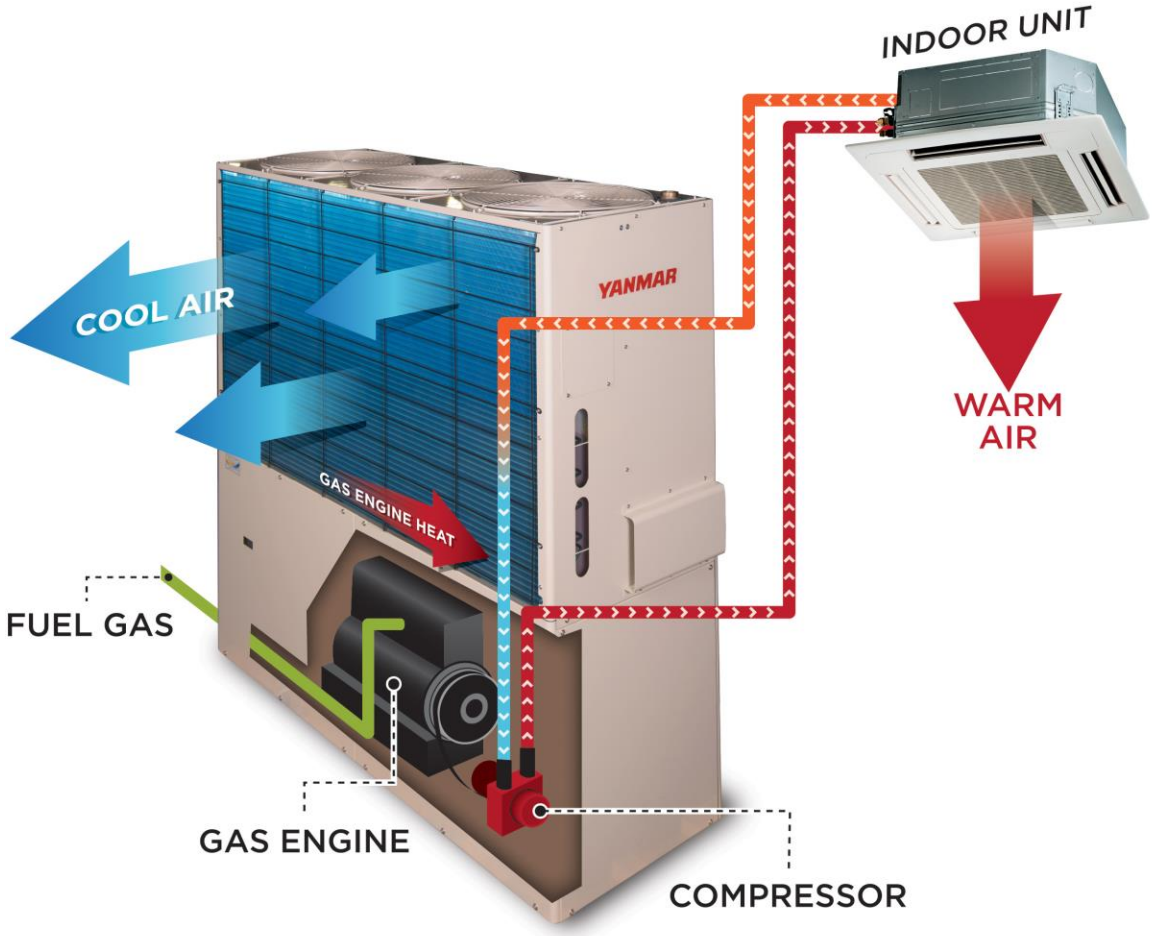
When the temperature drops during the winter months, the system receives a signal from the room thermostat to heat the designated areas.

The coils of the outdoor unit capture heat from outside area. Even at 0 degree F, there remains 85% usable heat in the air.

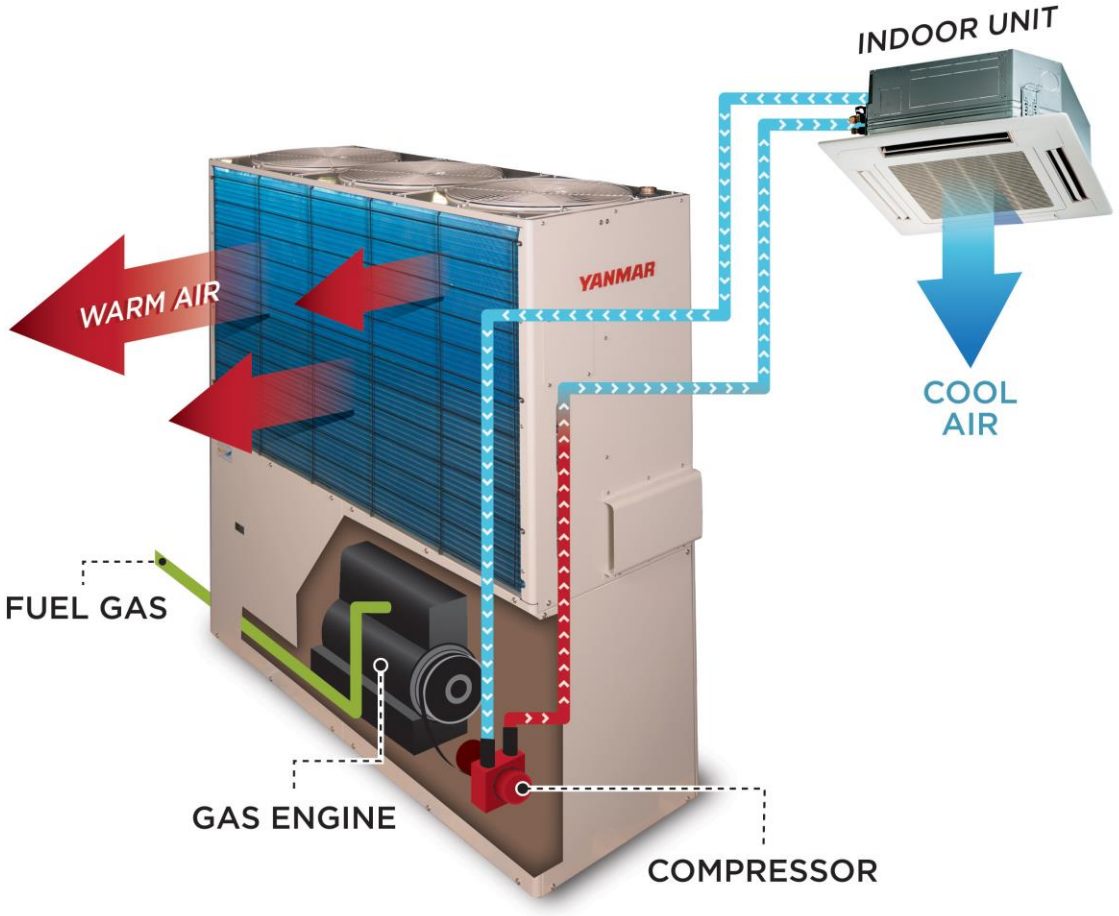
The heat is then transferred into the refrigerant and passed through the refrigerant lines to the indoor units.

The indoor unit fan motors then outputs the heat into the room.

As temperatures reach or drop below 0F, the heat created by the engine itself is also captured and cycled into the refrigerant circuit, effectively reducing energy consumption and costs.



YANMAR CHP: COOLING CYCLE



- During the summer months when the room warms above the designated temperature, the system receives the signal from the room thermostat to begin the cooling cycle.
- The coils of the indoor unit capture the heat from the ambient air and transfers it into the refrigerant lines and to the refrigerant.
- The heat is then passed through the refrigerant lines to the outdoor unit and into the outdoor coils.
- The outdoor fan motors then expel the heat into the outside air.

DESIGN FLEXIBILITY

- ADAPTABLE FOR ALL ENVIRONMENTS
  - IDEAL FOR RETROFITS
  - REDUCED ELECTRICAL INFRASTRUCTURE
- SUPERIOR PERFORMANCE
- GREATER EFFICIENCY
  - REDUCED PEAK DEMAND
- ZONE COMFORT
- DURABLE
- BEST WARRANTY IN THE INDUSTRY

ADAPTABLE TO ANY ENVIRONMENT Unlike conventional ductwork systems, YANMAR's indoor fan coil units are completely modular allowing for many design options, regardless of whether you're installing for the first time or upgrading an outdated system. Using a centralized thermostat, indoor fan coil units can be placed where they make sense for your business, rather than following the constraints of an existing duct system. Our systems are also a fit for any geographic setting. All YANMAR outdoor units come with a special coil coating, making them resistant to corrosion and able to take what any outdoor environment can dish out—including the salty air of coastal areas.

YANMAR GHP Maximum Efficiency = Dramatically Lower Overall Costs

ZONED COMFORT

The YANMAR GHP system allows users to create zoned comfort depending on the location and needs of a building's occupants. Our cost-saving configuration options allow for individual control of up to 29 zones on one piping network. This means that individual employees can manage their own thermostat comfort levels, and that unoccupied areas can have their own appropriate temperature settings, too. In fact, the thermostats are so smart that they can be programmed to take into account room occupancy and how much sunlight a space receives, assuring that the occupants' comfort level reflects real-world factors.

REDUCED ELECTRICAL INFRASTRUCTURE The YANMAR GHP consumes around 90% less electricity than a similar electric condenser, and operates on single-phase power, dramatically reducing electrical infrastructure and associated costs. No additional building upgrades required. If your site has limited power or you'd like to lower upgrade expenses, our modular systems can reduce the overall capital cost of the project, as well as required floor space, and keep saving you money as you use them.

GREATER EFFICIENCY Our system was designed from the ground up to increase efficiency and lower operating costs. Some features that exemplify this include: Engine Heat Recovery technology allows for faster heating than with EHP systems. In low ambient temperatures, YANMAR GHP provides more efficient heating performance by using waste heat energy . A modular system means heating and/or cooling only the zones that need it.

REDUCED PEAK DEMAND The use of air-conditioning continues to grow at a rapid rate globally, creating a steep rise in demand for power, fears of shortages during peak usage and regulations that penalize high-energy use. YANMAR's GHP systems help avoid peak demand charges, which can make up over 50% of the overall cost of air conditioning, thereby significantly reducing operating costs. Lowering demand profiles in this way can help customers negotiate competitive rates from their electricity supplier .

DURABILITY // Factory-backed GHP warranty coverage. // Proven technology with more than 260,000 gas engine GHP units installed worldwide over the past 29 years. // The outdoor unit's packaging design protects critical unit components from the environment.

Yanmar VRF

- Gas Furnace
  - 100,000 btu IN > 95,000 btu OUT
  - Gives you 95% Efficiency
- Gas Heat Pump
  - 100,000 btu IN > 142,000 btu OUT
  - Comparably is 142% Efficient!

Applications

- IDEAL FOR RETROFITTING YANMAR's GHP units offer a remarkably flexible solution, even for older buildings. While the cost of replacing a heat pump or air conditioning system with a traditional EHP system would be insurmountable for some businesses, our gas-powered systems can be added on to what you already have, saving you in energy and installation costs over the lifetime of the product.

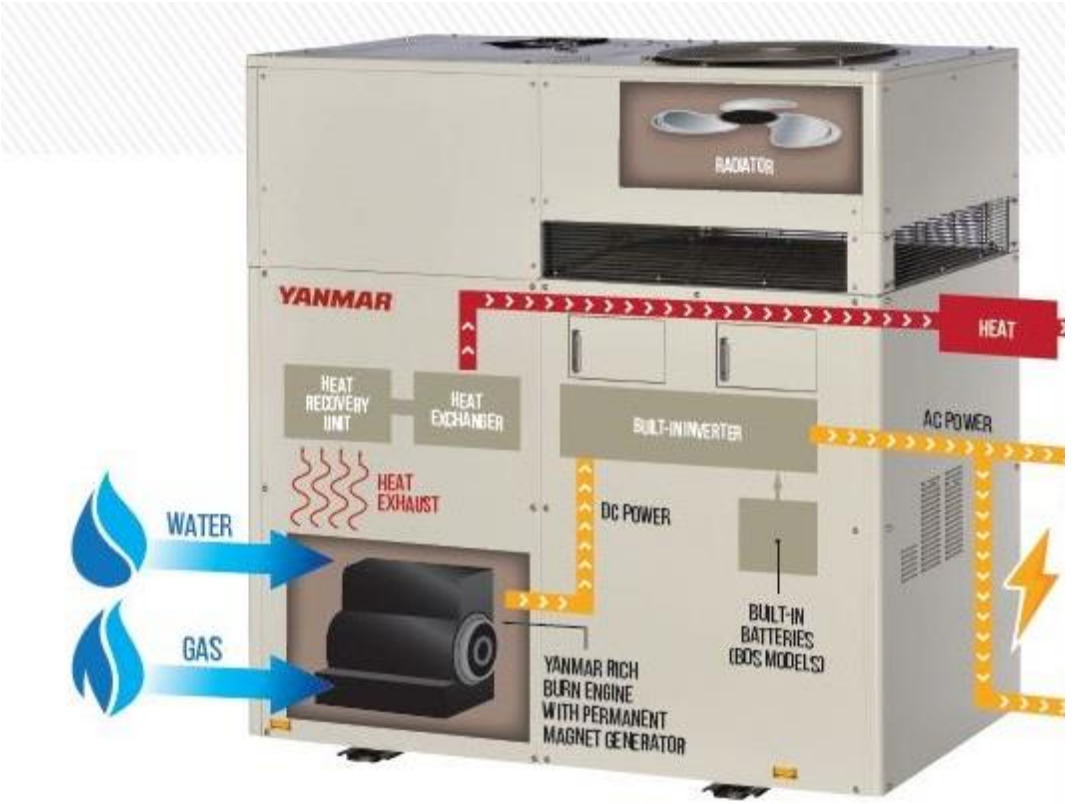
Cogeneration (CHP)

What is Combined Heat & Power Technology?

- **Combined Heat and Power** (CHP), also known as cogeneration, is: The concurrent production of electricity or mechanical **power** and useful thermal energy (**heating** and/or cooling) from a single source of energy.
- Simply the Simultaneous Production of Electricity and Heat from a Single Fuel Source.
- It's a Cost Effective, Energy Efficient and Environmentally Friendly Way of Providing Utilities to your Facility.
- Cost-Effective Means to Help Control Electric Demand and reduce consumption.
- Onsite Generation is More Efficient than the Utilities: Electricity is generated close to the point of use, helping to avoid transmission and distribution losses that occur when electricity travels over power lines.
- Mechanical Cogeneration
  - The simultaneous production of shaft power and heat. A prime mover (in many cases, an internal combustion engine) turns a shaft to produce shaft work, and heat is recovered from the prime mover and purposefully reused.
  - The shaft power output from the engine is used to operate an Air Conditioning Unit and the waste heat is used to heat the facility, or make Hot Water.
  - It's a Cost Effective, Energy Efficient and Environmentally Friendly Way of Heat and Cool your Facility.
  - Cost-Effective Means to Help Control Electric Utility Cost.
  - Uses Cost Effective Natural Gas Reducing your electricity Demand and Consumption.

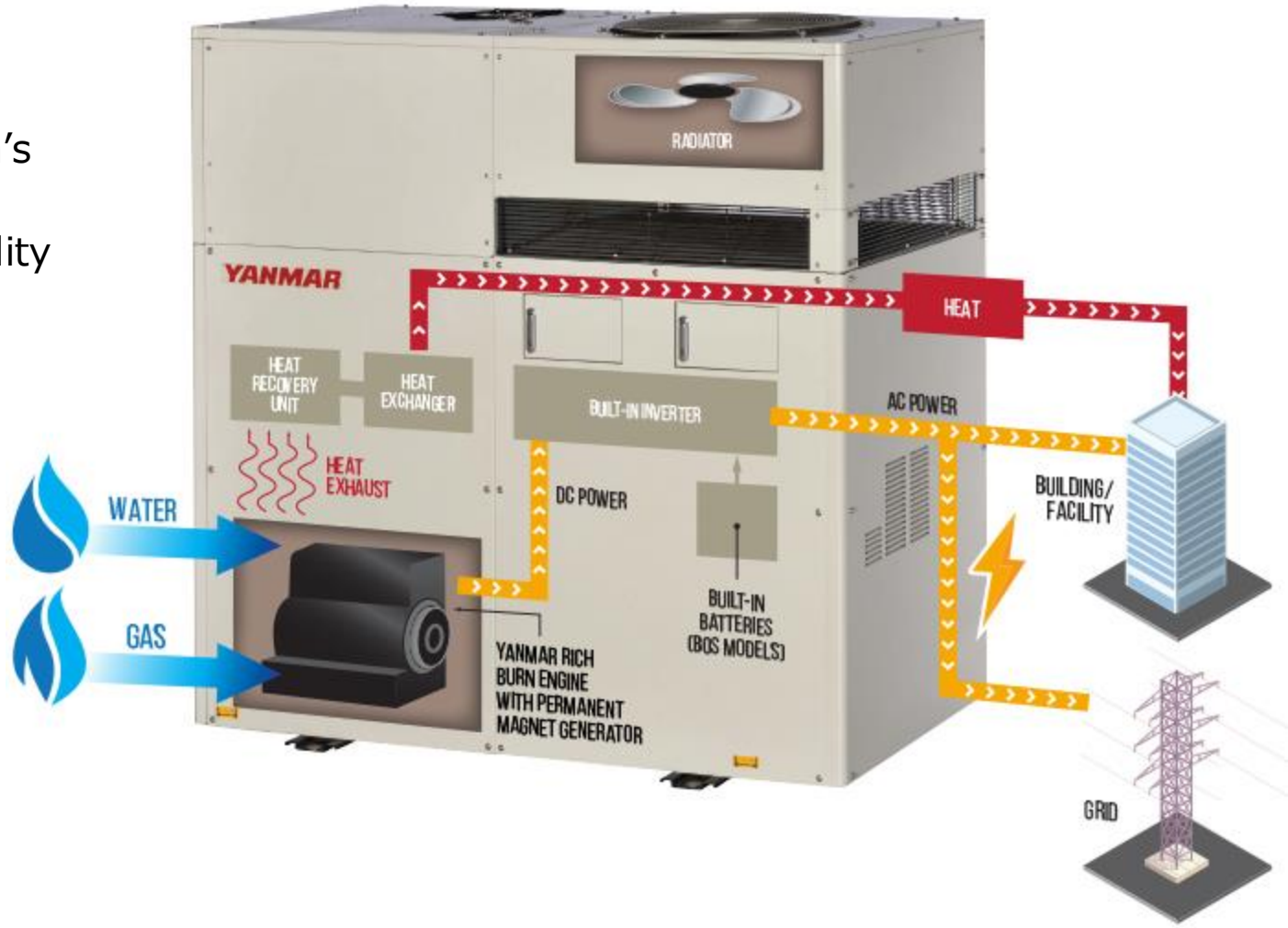
Combined Heat and Power (CHP)

When thinking about heat and power for commercial buildings, traditionally two important, but separate, systems come to mind—one for hot water and one for electricity. Combined Heat and Power (CHP) systems revolutionizes this by combining two independent functions into one comprehensive system. Using natural gas, CHP system generates heat with on or off-grid electricity as a by-product of this process. When compared to using hot water boilers in conjunction with conventional power from the grid,the environmentally-friendly system is over 50% more efficient.



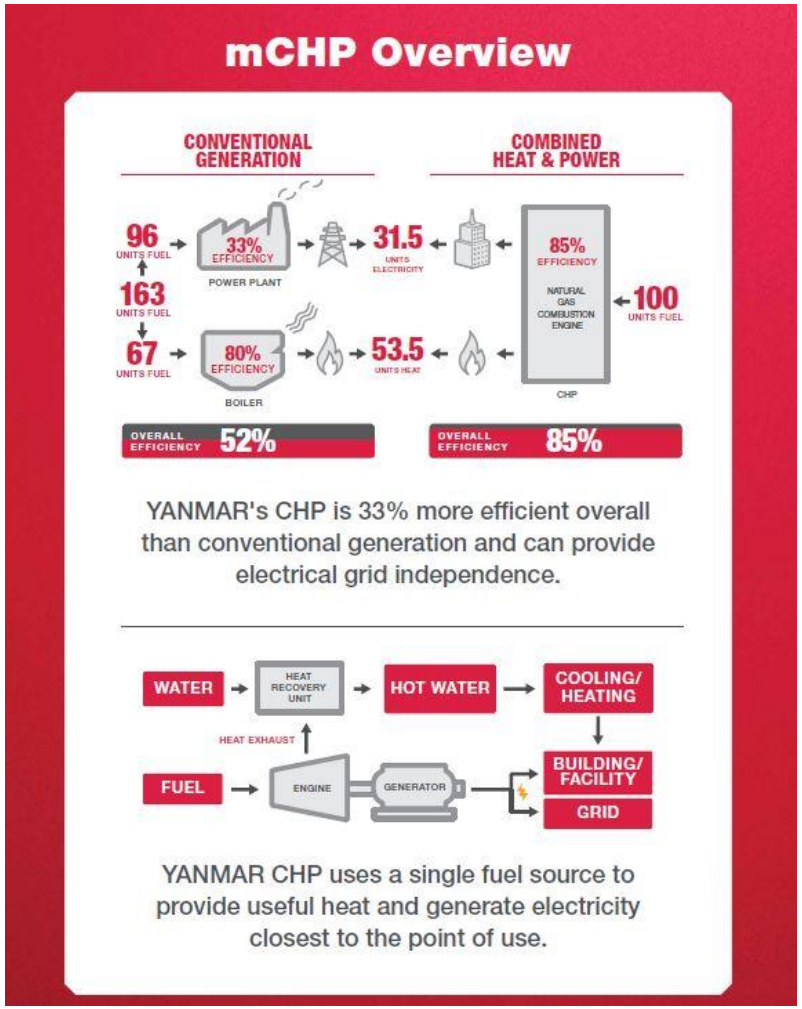
Benefits of CHP

- Reduce Electric Bill
  - "Slow The Meter Down" to Offset Retail Electric Rates
- Reduce Boiler Gas Bill
  - Preheat Boiler Return Water with Cogen's Free Waste Heat
- Reduce Exposure to Future Utility Price Volatility
- Low Emissions
  - Meets Current SCAQMD Air Quality Standards
- Quiet Operation
- Compact Design
- Heat Recovery Capability
  - Engine Jacket, Oil, and Exhaust Gas

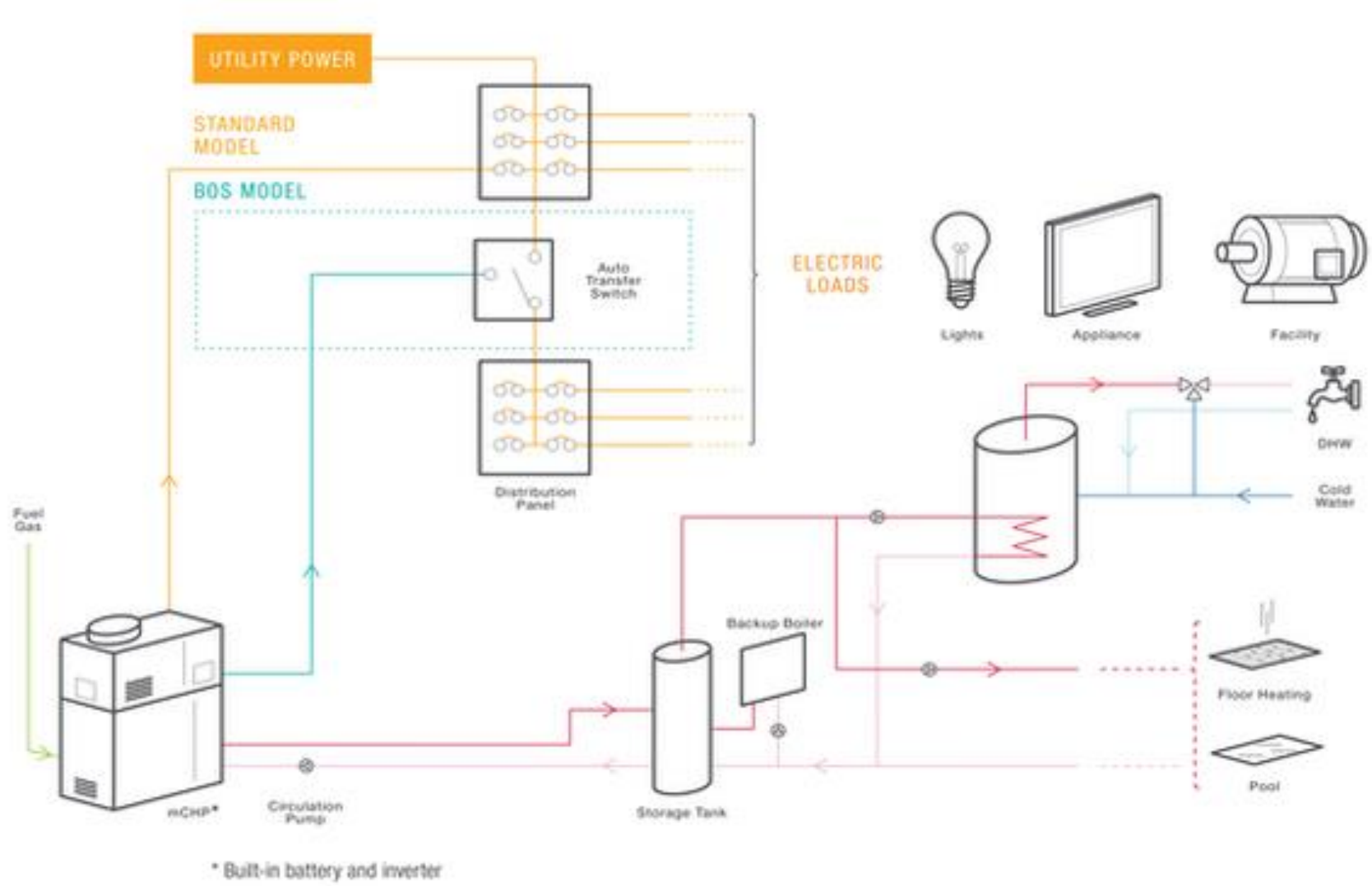


YANMAR CHP

- YANMAR CHP (Combined Heat & Power) has the following advantages over traditional energy delivery methods of centralized power plants and onsite gas use:
- Onsite Generation: Electricity is generated close to the point of use, helping to avoid transmission and distribution losses that occur when electricity travels over power lines. YANMAR CHP with Blackout Start (BOS) capability can provide electricity even when the grid has failed due to storms or other factors.
- Waste Heat Recovery: Thermal energy from space heating, domestic hot water heating, pool/spa heating and dehumidification or process applications goes unused in centralized power plants as waste, but in YANMAR CHP applications, it is used to offset boiler or other heating device usage.
- Simple Integration: YANMAR CHP can be easily integrated into various electrical and thermal systems in small commercial or residential applications, including new construction and retrofitting into existing buildings.



YANMAR Cogeneration

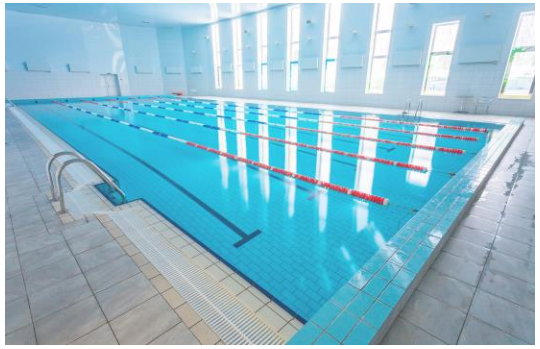


TEDOM

- The TEDOM CHP units burn not only natural gas or LPG, but also various types of biogas. This is produced, for example, from the decomposition of biomass in agricultural biogas plants, municipal waste landfills or in the process of waste water treatment. The mine gas generated from coal mining or in closed mines, or the associated gas from the oil extraction, can also be used to generate the power.
- We offer gas CHP units with electric power ranging from 30 kW to 4.5 MW.

Applications

- Applications of combined heat and power structures include the **generation of heat, cooling, hot and chilled water** in commercial, institutional and residential buildings, as well as a multitude of industrial facilities.
- Combined heat and power (CHP) is an energy technology that's best suited for facilities with year-round consistent thermal and electric loads. CHP is used in a variety of applications, including:
  - **Industrial**
    - CHP is commonly used in energy-intensive industrial sectors like chemicals, paper, refining, food processing, and metals manufacturing.
  - **Commercial**
    - CHP is used in commercial buildings like office buildings, hotels, nursing homes, and retail.
  - **Institutional**
    - CHP is used in institutions like colleges and universities, hospitals, prisons, and military bases.
  - **Residential**
    - CHP is used in residential applications like multifamily buildings, co-ops, and planned communities.
  - **Municipal**
    - CHP is used in municipal applications like district energy systems and wastewater treatment facilities.



Trigeneration

- Trigeneration, also known as combined cooling, heat, and power (CCHP), is the process of generating electricity, heat, and cooling simultaneously from a single fuel source. Trigeneration systems are more efficient than conventional power plants and can provide significant environmental and financial benefits.
- Trigeneration systems work by integrating a thermally driven refrigeration system with a combined heat and power (CHP) or co-generation system. The heat produced by the cogeneration plant is used to generate chilled water for air conditioning or refrigeration.
- Trigeneration systems can be profitable investments for building owners and industrial plants. They can help reduce power requirements on the electric grid, increase power reliability, and reduce dependence on foreign oil. A new trigeneration system can pay for itself in as little as two years.
- Benefits to trigeneration including:
  - Onsite, high efficiency production of electricity and heat
  - Reduced fuel and energy costs
  - Lower electrical usage during peak summer demand
  - Engine heat can be used to produce steam of hot water for onsite use
  - Significant reductions in greenhouse gas emissions

Maritime Aquarium Trigeneration Project

- one (1) YAZAKI Water Fired Single Effect Chiller.
- One (1) TEDOM CENTO 200 Natural Gas C LB 60Hz Cogeneration/CHP unit.
- one (1) Heat Exchanger (HX-1) as specified in drawings.
- three (3) Inline Centrifugal Pumps (P-1,2,3) as specified in drawings. Includes VFDs for the pumps.
- one (1) Air Separator (AS-1) as specified in drawings.
- one (1) Glycol Feed System
- one (1) Expansion Tank (ET-1
- Piping as specified in drawings.
- One concrete maintenance pad for the new Yazaki Electrical
- Distributed Generation Metering/Test Switches/Shunt Trip Operator.
- JCI controls for new equipment
- Gas Meter

Maritime Aquarium Trigeneration Project

- Based on the model, we are proposing one (1) 200 kW Tri-gen system – which can save up to **57%** of the building's electrical load and **86%** of the thermal load.
- The energy savings was based on past utility bills. Based on the Tri-gen system running 7,884 hours (with 90% uptime), the estimated total utility savings are **$379,773**, while the estimated operational cost is **$264,670**. There is also a possibility of earning **$28,860** in incentives. The total estimated annual savings including incentives are **$143,962**.
- Considering the project cost to be **$1,307,075**, with a 30% Investment Tax Credit (ITC), the simple payback is **6.36 years** (9.08 years without the ITC). The savings to investment ratio (SIR) for a period of 20 years, which is the useful equipment life, is 1.28.

(1) Tedom Cento - 200 kW – Performance Summary

		Blended Unit Cost	Total Savings/Expense
Electric Offset	1,835,228 kWh	$ 0.18 / kWh	$335,058
Thermal Offset	29,817 ccf	$ 1.50 / ccf	$44,714
CHP Gas Input	137,587 ccf	$ 1.50 / ccf	$(206,328)
Annual CHP Maintenance	7,884 Hrs	$ 7.40 / Hrs	$(58,342)

Future Annual Savings: $115,103

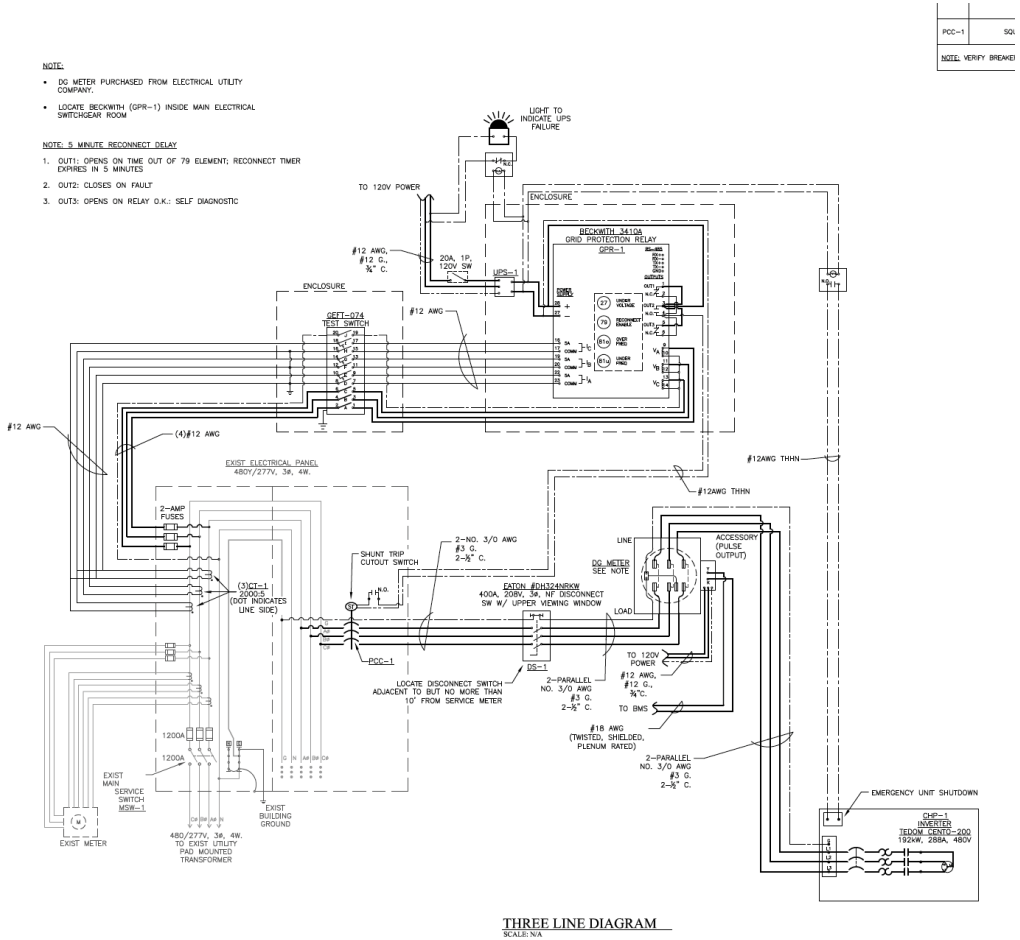
Project Economics

Total Project Cost	$1,307,075
Total Possible Incentives	$28,860
1st Year Savings	$379,773
1st Year Expenses	$(264,670)
Net Annual Savings	$115,103
Investment Tax Credit (30%)	$392,123

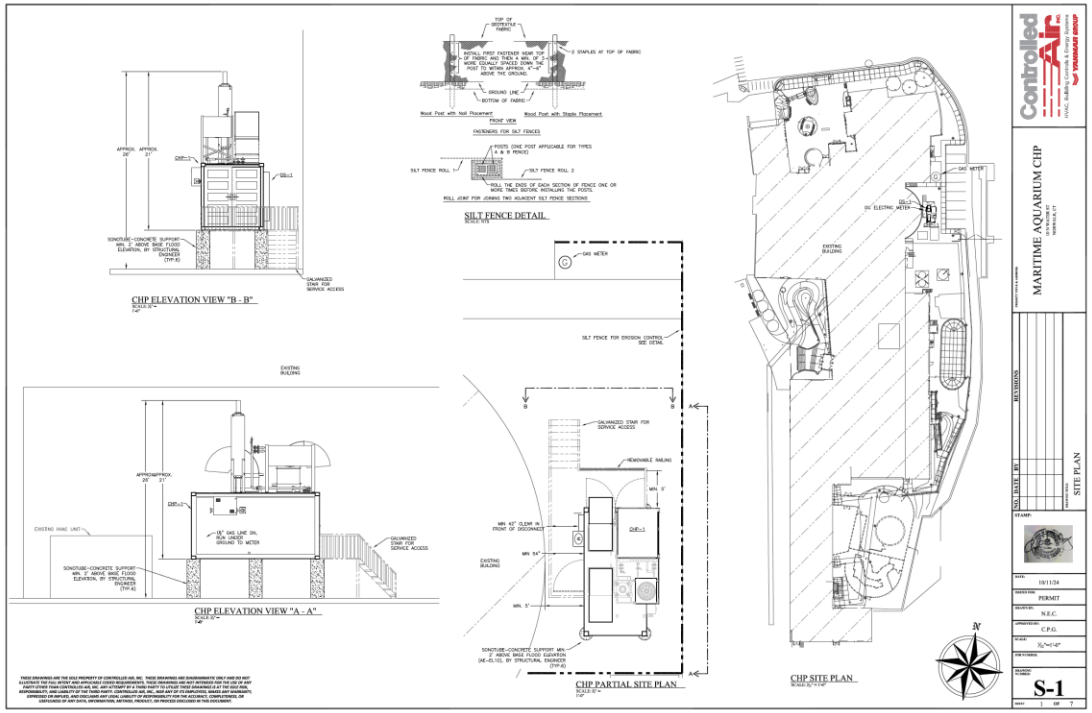
Payback: 6.36 Years*

Maritime Aquarium Trigeneration Project

Maritime Aquarium Trigeneration Project



THREE LINE DIAGRAM
SCALE: N/A



Microgrids

- Cogeneration, solar and batteries can be combined with HVAC and controls to create a nanogrid in a single building where energy use and outages are a concern.
- We can develop turnkey energy, microgrid and nanogrid solutions from 35kw to 3MW.
- We utilize full scale microgrid systems, miniaturized to manage and incorporate multiple energy technologies to meet the needs of each specific customer, and installed in a single building.
- Nanogrids can be installed in new construction, as well as updating older inefficient buildings.
- These nanogrids allow for smaller high energy use buildings to remain operational during outages, as well as providing heat, hot water and electricity for daily use.

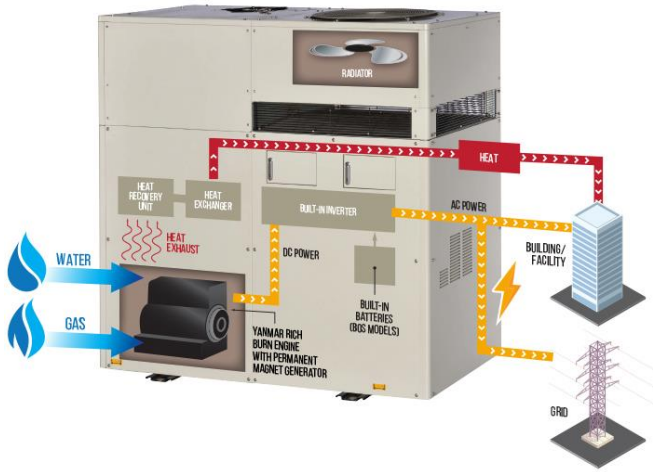
Bridgeport Microgrid
The Microgrid is a combination of CHP system and electrical power network designed to provide continuous power even in times of natural disasters or when the main electrical grid fails. The project is part of a municipal pilot program launched through the State Department of Energy and Environmental Protection in 2013. The Microgrid was built with 100% grid redundancy at no cost to the city, with the potential for reducing environmental impact and long term energy costs.

Combined Heat & Power CHP with Controlled Air, Inc.

Controlled Air Offers:

- We provide boutique energy solutions through our partnerships and in-house knowledge.
- Leverage all incentives and credits to lower initial costs.
- Cogeneration systems are cost-effective, highly reliable, easy to maintain, compact and quiet.
- Cogeneration has the quickest Return-on-Investment of any energy savings program, with many systems paying for themselves within 2-5 years. An added benefit of cogeneration is that the more energy you use, the quicker the return on investment.
- There are many federal and state incentives and rebates currently available to make changing your system over to cogeneration even more affordable.

- Controlled Air, Inc. can provide cogeneration units ranging in size from 30 kW to 650 kW. Applications include hospitals, schools and colleges, athletic clubs, swimming pools, hotels & motels, apartments and condos and food & beverage environments. For more information about cogeneration or to find out how it can help you save money on utilities call Controlled Air



Examples

Examples

Middletown Recreation Center

This project began as an endeavor to preserve a portion of a middle school destined for demolition, but it evolved into something far greater—a dynamic recreation center and a vital refuge during neighborhood emergencies such as power failures. As we delved into the feasibility study, a vision emerged of this building as an energy-generating system that would also serve the surrounding neighborhoods in times of dire necessity.

Elm City Bioscience Center

Controlled Air Inc. provided mechanical design build support to the Elm City Bioscience building infrastructure upgrades located in New Haven. The bioscience building is 113,620 sq ft which includes 8 stories plus a lower level and mechanical penthouse. The project will be on-going with multiple floors being converted from smaller office spaces to larger open lab space and smaller office areas.

Financing, Rebates & Incentives

Rebates & Financing

Public Benefit Funds in Connecticut such as CEEF (Connecticut Energy Efficiency Fund) and CMEEC (Connecticut Municipal Electric Energy Consortium), frequently offer rebates on certain energy efficiency upgrades for items such as restaurant equipment, refrigeration, lighting, appliances, co-generation per KW purchased, etc. Rebates are a stated amount of cash that will be paid to you once a project is completed. The rebate will typically require a form to be completed, and often a receipt for payment and a contractor's signature verifying work completion will be required as well.

Potential CHP rebates:

- Class 3 Rec - DEEP
- Passive Demand Response – CPOWER (ISO New England)

Financing & Economics of Energy

- Federal and State tax credits
- Federal depreciation and tax deductions
- State sales tax exemptions
- Local property tax exemptions
- Rebate programs
- Cash incentives, including Public Benefit Funds
- The Demand Response Program

Options to Finance Energy Measures

- Direct Purchase
- Financing through Bank & Capital Companies
- Leasing
- Power Purchase Agreements (Primarily for renewable energy generation)
- Energy Service Agreement (Focuses on energy efficiency upgrades)
- Performance Based Financing through ESCOs (Energy Service Company)
- Direct Lending through Public Benefit Funds (PBFs): Green Bank
- Mission Based Lenders focusing on clean energy (National Energy Improvement Fund - NEIF)
- PACE or C-PACE programs (Property Assessed Clean Energy/Commercial PACE)

Questions?