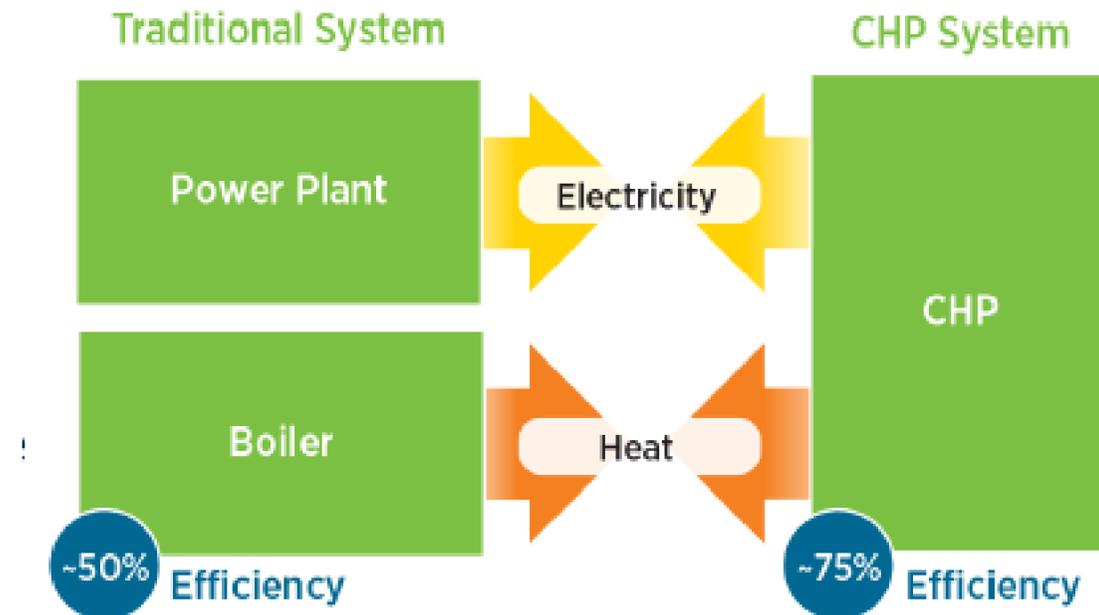


verde
SOLUTIONS

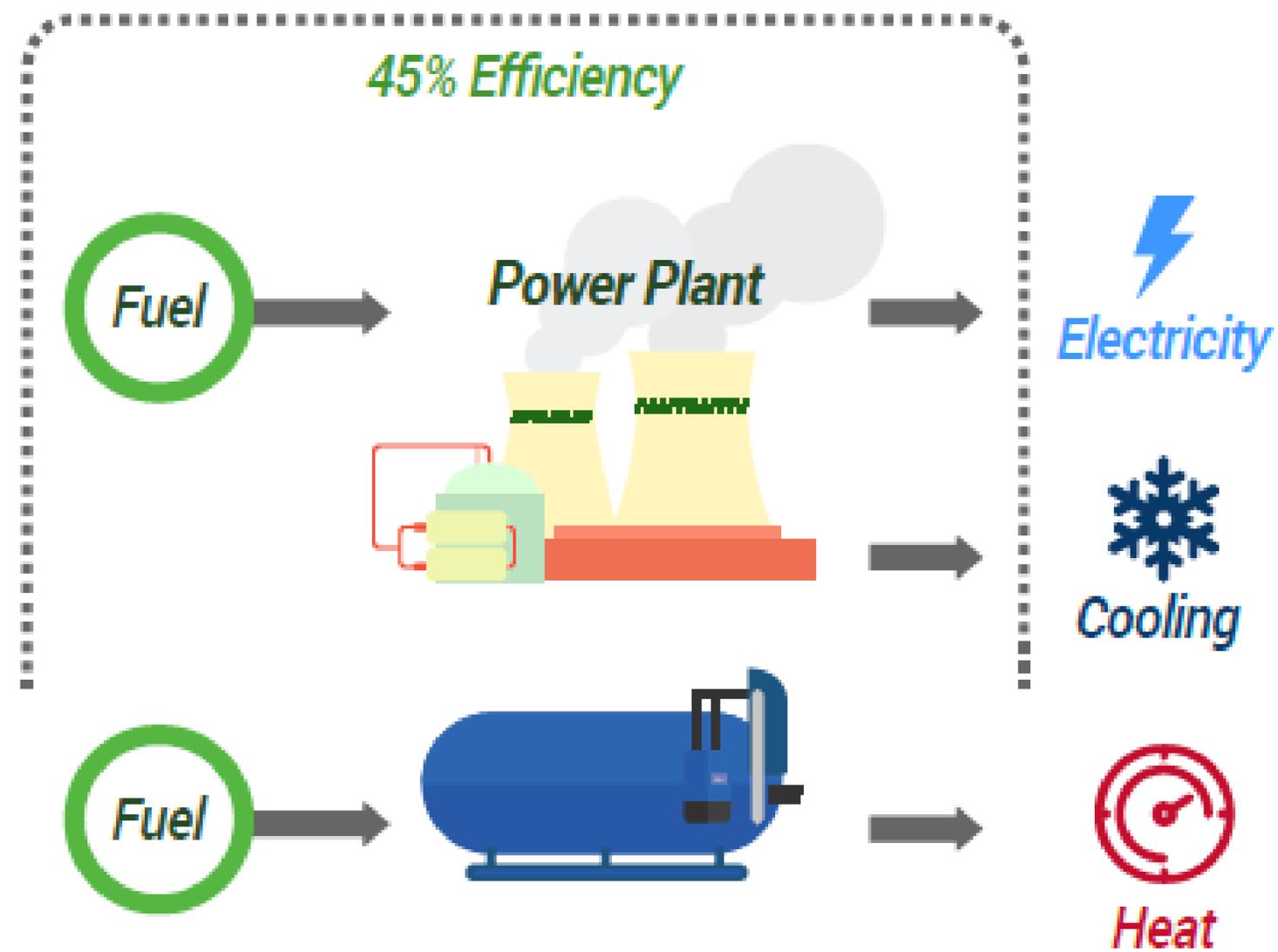
CHP Training 2019

Combined Heat & Power (CHP) is the simultaneous generation of usable heat and power within a single process. The power generated is usually electricity but can also be mechanical power for driving equipment such as pumps, compressors, and fans.

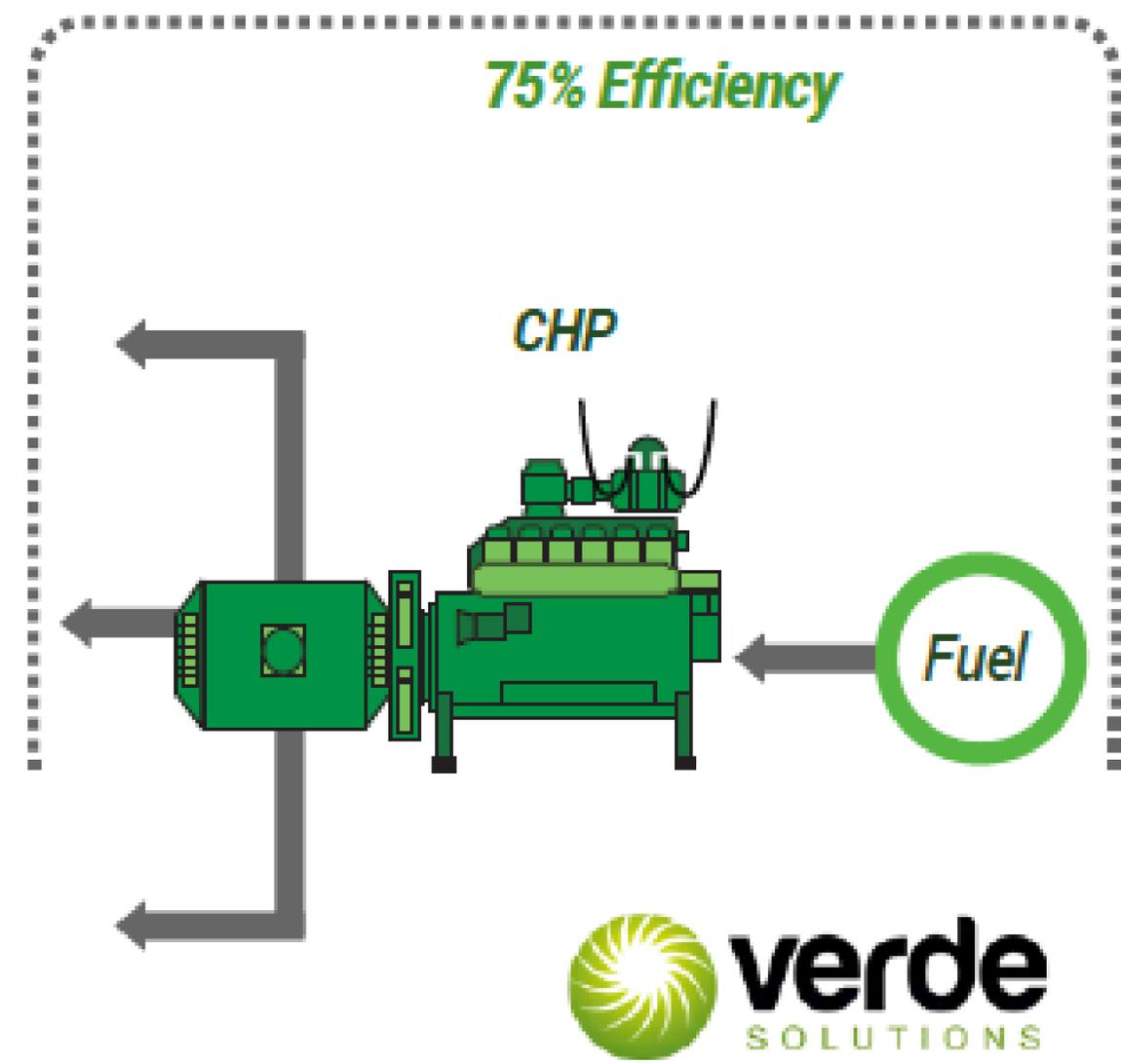


CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Traditional System

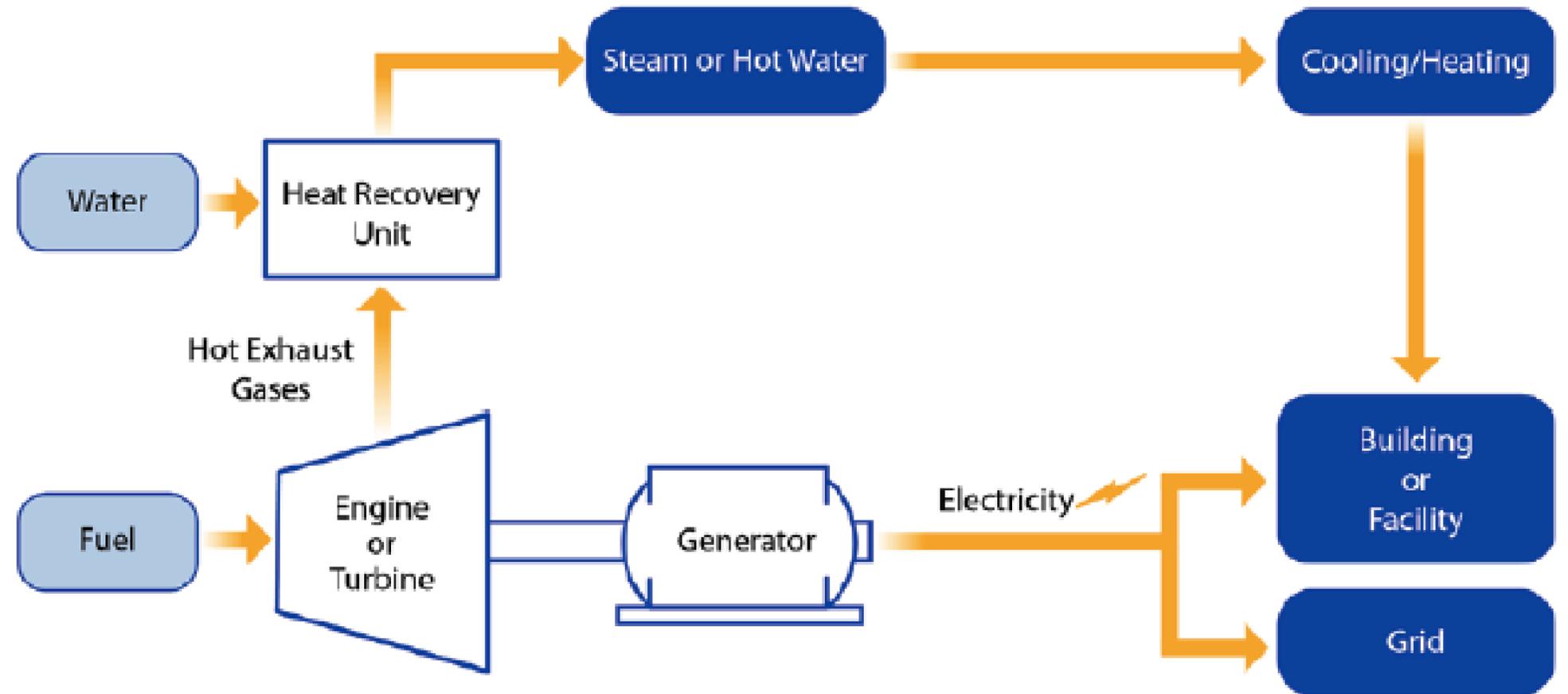


Co-Gen System



CHP systems can provide the following products:

- Electricity
- Direct mechanical drive
- Steam or hot water
- Process heating
- Cooling and refrigeration
- Dehumidification



What are the benefits of CHP?

More efficient than separate generation of electricity and heating/cooling

Higher efficiency translates to lower operating costs (but requires capital investment)

Higher efficiency reduces emissions of pollutants

CHP can also increase energy reliability and enhance power quality



- Technology: **Gas Micro-Turbine**
- Technology Partner: Capstone
- Modulated based on its compact size



- Technology: **Gas Combustion Turbine**
- Technology Partner: Kinsey
- Less Modulated



- Technology: **Reciprocating Engine**
 - True and proved CHP technology
 - Last 'forever'

Turbine vs Engine

Turbine = more efficient at producing electricity

Engine = more efficient at producing heat



2 MW Engine System
Hospital Site

15 MW Gas Turbine
Ethanol Plant



Remember

Without long hours of operation (>3,000 hrs/yr) and at least 50% usage of the recycled heat (annual basis), the viability of CHP is low.

Ideal CHP Opportunity

- Blended electricity rate higher than \$0.10/kWh
- Gas rate lower than \$0.60/therm
- Client has large heating/cooling loads

Things to Avoid

- Little to no hot water use
- No natural gas on site
- Blended electrical rate is lower than \$0.10/kWh
- Gas rate is higher than \$0.60/therm

Remember

The best time to install a CHP system is when contemplating replacement of aging equipment or facility upgrade

Boilers (steam/water) or Chillers (electric/absorption)

- Capacity
- Age
- Fuel Type

Central Heating/Cooling Plant

- Type Distribution System (steam, water, air)
- Steam (operating temp., pressure, flow rates)
- Very attractive

Water (delivery temperature)

- Proximity of equipment to potential CHP installation

- Is there a use for the CHP waste/recycled heat?
- Is there a major thermal equipment change or replacement planned?
- Is there a sufficient “spark spread”?
- Identify size and type of prime mover to meet thermal requirements (high efficiency).
- Will the selected configuration provide adequate waste heat levels for the facility’s heating and/or cooling needs?
- Are there potential installation issues such as space constraints on site?
 - How will these issues impact the installation costs?
- What do basic economics of the project look like for the client?
 - Most clients do not pursue CHP for the image of going green
- Is the application worth pursuing with a formal analysis?



Industrial

- Chemical manufacturing
- Ethanol
- Food processing
- Natural gas pipelines
- Petrochemicals
- Pharmaceuticals
- Pulp and paper
- Rubber and plastics



Commercial

- Data centers
- Hotels and casinos
- Multi-family housing
- Laundries
- Apartments
- Office buildings
- Refrigerated warehouses
- Restaurants
- Supermarkets
- Green buildings



Institutional

- Hospitals
- Landfills
- Universities & colleges
- Wastewater treatment
- Residential confinement



Agricultural

- Concentrated animal feeding operations
- Dairies
- Wood waste (biomass)

- Hospitals
- Light Industrial
- Apartments/Condos
- Community Colleges
- Large Schools
- Nursing Homes
- Community Centers
- Athletic Clubs
- Municipal Pools
- Correctional Institutions



- Mid-stream Oil & Gas Processing
- Oil Refineries
- Chemical Plants
- Heavy Industrial
- Hospital Campuses
- College Campuses





CHP Proposal

Preliminary Proposal



Prepared for:
CLIENT INFORMATION

Prepared by:
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Chicago, IL 60614
800.541.1137
leads@verdesolutions.com

Verde Solutions is pleased to present this Combined Heat and Power (CHP) proposal for your review. This proposal is based on preliminary information to provide an initial suggested system configuration, size, and budgetary estimate. A final proposal with sizing and firm pricing will be provided after all required information has been received and validated.

Input Parameters & Assumptions	
Current Annual Energy Consumption	184,000 kWh / year
Blended Utility Electricity Rate	\$0.118/kWh
Blended Utility Gas Rate	\$0.96/Therm
Peak Demand	71 kW

Overview
Based on review of your usage information, available space for installation, and utility constraints, the proposed system has a peak power rating of 65 kW. The system is estimated to produce 184,000 kWh/year which will offset approximately 99% of your current annual energy consumption.

System Size	1 modules
System Module Power Capacity	65 kW
Projected Annual Energy Production	183,900 kWh / year
Ratio of Current Consumption Offset with CHP System	100%
Estimated Useful Lifespan	30 Years

Investment Overview
Currently there are two federal tax credit programs, the Business Energy Investment Tax Credit (ITC) and the Federal MACRS, Bonus Depreciation, which significantly reduce the net after-tax cost of the system investment. The ITC can be applied 1-year back and up to 20-years forward, per IRS rules. All state and utility incentives have been included.

System Investment / Proposal	\$232,700 total turnkey installation cost (\$3.58/Wp)
CHP Business Energy Investment Tax Credit	(\$13,000)
Federal MACRS, Bonus Depreciation - 40% (2018)	(\$67,860)
AEP CHP Incentives	(\$ 7,176)
Net Investment After Incentives	\$144,664 net after-tax investment



CHP Proposal

Economic Summary

Internal Rate of Return (IRR)	9.7% per year
Annual Energy Savings	\$19,238 year 1
Reduction in Energy Bill	88.8% reduction
Payback Period	10.7 Years

- **Internal Rate of Return (IRR)** - Used to estimate profitability of investment. An effective "interest rate" equal in value to the after-tax cash flows the system is projected to generate. If the IRR is greater than the business cost of capital, the investment may be attractive.
- **Annual Energy Savings** - The amount of money saved on utility bill the first year the system is installed. This value is expected to increase over time as the cost of energy increases.
- **Reduction in Energy Bill** - The expected average percentage an electric bill will decrease the first year. Due to seasonal variance, this value will change month to month.
- **Payback Period** - The length of time required to recover the cost of the investment.

Project Installation

Implementation of the project can begin immediately starting with a detailed site assessment from one of our field engineers moving into full engineering and design. Concurrently, Verde Solutions will work with you and handle all required building & electrical permits, utility interconnection applications, incentive applications (if applicable) and any other needs as they arise.

Materials will be ordered after the design is finalized. Each project is designed and built to suit. Once the materials are on-site, installation begins with final system testing and commissioning as the last steps.

Disclaimer

This proposal includes forecasts, projections and other predictive statements resulting from an analysis by Verde Solutions of the information provided by the prospective client as well as information from Verde Solutions' operations and what is available within the marketplace. Prospective clients should recognize that the forecasts, projections and other predictive statements stated herein, although based upon information and assumptions that Verde Solutions believes to be viable and accurate, are projections and that Verde Solutions does not provide any guarantees for the achievement by the prospective client of the projections noted herein. The prospective client must realize that in the development of any projection there are certain factors that are unforeseen at the time the projection is made and thereby there are certain risks involved that provide for uncertainty. The prospective client's actual performance results may differ from those projected in this proposal. Therefore, there is no guarantee presented or implied as to the accuracy of any specific forecast, projection or predictive statement contained herein.

Calculations illustrating tax savings and deductions are estimates only. Please consult your tax expert regarding tax advantages specifically available for your organization.

Ground based systems may require additional investments in fencing and/or landscaping, which are not included.

C65 Microturbine

High-pressure Natural Gas



Achieve ultra-low emissions and reliable electrical generation from natural gas.

- + Ultra-low emissions
- + One moving part – minimal maintenance and downtime
- + Patented air bearings – no lubricating oil or coolant
- + Integrated utility synchronization – no external switchgear
- + Compact modular design allows for easy, low-cost installation
- + Multiple units easily combined – act as single generating source
- + Remote monitoring and diagnostic capabilities
- + Proven technology with tens of millions of operating hours
- + Various Factory Protection Plans available



C65 Microturbine

Electrical Performance⁽¹⁾

Electrical Power Output	65kW
Voltage	400 /480VAC
Electrical Service	3-Phase, 4 Wire Wye
Frequency	50/60 Hz
Electrical Efficiency LHV	29%

Fuel/Engine Characteristics⁽¹⁾

Natural Gas HHV	30.7–47.5 MJ/m ³ (825–1,275 BTU/scf)
Inlet Pressure	517–551 kPa gauge (75–80 psig)
Fuel Flow HHV	888 MJ/hr (842,000 BTU/hr)
Net Heat Rate LHV	12.4 MJ/kWh (11,800 BTU/kWh)

Exhaust Characteristics⁽¹⁾

NOx Emissions @15% O ₂	< 9 ppmvd (19 mg/m ³)
Exhaust Mass Flow	0.49 kg/s (1.08 lbm/s)
Exhaust Gas Temperature	309°C (588°F)

Dimensions & Weight⁽²⁾

Width x Depth x Height ⁽³⁾	0.76 x 1.95 x 1.91 m (30 x 77 x 75 in)
Weight - Grid Connect Model	758 kg (1,671 lb)
Weight - Dual Mode Model	1,121 kg (2,471 lb)

Minimum Clearance Requirements⁽⁴⁾

Horizontal Clearance	
Left & Right	0.76 m (30 in)
Front - Grid Connect Model	0.76 m (30 in)
Front - Dual Mode Model	1.65 m (65 in)
Rear	0.91 m (36 in)

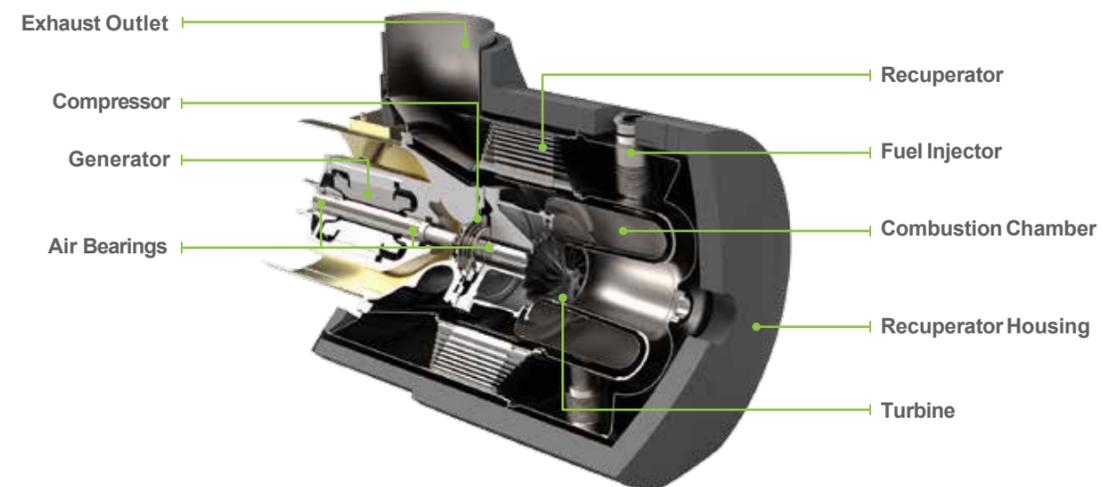
Acoustic Emissions

Nominal at Full Power at 10 m (33 ft) ⁽⁵⁾	70 dBA
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Certifications

- UL 2200 Listed
- CE Certified
- Certified to the following grid interconnection standards: UL 1741, VDE, and BDEW
- Compliant to California Rule 21

C65 Engine Components



(1) Nominal full power performance at ISO conditions: 15°C (59°F), 14.696 psia, 60% RH
(2) Approximate dimensions and weights
(3) Height dimensions are to the roofline. Exhaust stack extends at least 178 mm (7 in) above the roofline
(4) Clearance requirements may increase due to local code considerations
(5) The optional acoustic inlet hood kit can reduce acoustic emissions at the front of the Microturbine as much as 5 dBA
Specifications are not warranted and are subject to change without notice.





CHP Proposal

No escalation-market indicates that the cost of fuel will steadily decrease not increase.

Cash Flow Analysis											
Years	Cash						Generation (kWh)	Federal Taxes		Total Cash Flow	Cumulative Cash Flow
	Project Costs	Additional Fuel	Heating Savings	O&M	CHP Incentive	Electric Bill Savings		Income Decrease (Federal - MACRS Bonus Depreciation)	Federal Tax Credit		
Upfront	-\$232,700	-	-	-	\$7,176	-	-	-	-	-\$225,524	-\$225,524
1	-	-\$8,288	\$4,440	-\$230	-	\$19,238	184,000	\$35,287	\$13,000	\$63,448	-\$162,076
2	-	-\$8,288	\$4,440	-\$1,610	-	\$19,716	183,080	\$13,029	-	\$27,288	-\$134,789
3	-	-\$8,288	\$4,440	-\$230	-	\$20,206	182,160	\$7,817	-	\$23,946	-\$110,843
4	-	-\$8,288	\$4,440	-\$1,610	-	\$20,707	181,240	\$4,689	-	\$19,938	-\$90,905
5	-	-\$8,288	\$4,440	-\$18,630	-	\$21,220	180,320	\$4,689	-	\$3,431	-\$87,473
6	-	-\$8,288	\$4,440	-\$1,610	-	\$21,745	179,400	\$2,348	-	\$18,635	-\$68,838
7	-	-\$8,288	\$4,440	-\$230	-	\$22,283	178,480	-	-	\$18,205	-\$50,634
8	-	-\$8,288	\$4,440	-\$1,610	-	\$22,833	177,560	-	-	\$17,375	-\$33,259
9	-	-\$8,288	\$4,440	-\$230	-	\$23,396	176,640	-	-	\$19,318	-\$13,941
10	-	-\$8,288	\$4,440	-\$20,010	-	\$23,972	175,720	-	-	\$114	-\$13,826
11	-	-\$8,288	\$4,440	-\$230	-	\$24,562	174,800	-	-	\$20,484	\$6,658
12	-	-\$8,288	\$4,440	-\$1,610	-	\$25,166	173,880	-	-	\$19,708	\$26,366
13	-	-\$8,288	\$4,440	-\$230	-	\$25,784	172,960	-	-	\$21,706	\$48,071
14	-	-\$8,288	\$4,440	-\$1,610	-	\$26,416	172,040	-	-	\$20,958	\$69,029
15	-	-\$8,288	\$4,440	-\$18,630	-	\$27,063	171,120	-	-	\$4,585	\$73,614
16	-	-\$8,288	\$4,440	-\$1,610	-	\$27,725	170,200	-	-	\$22,267	\$95,881
17	-	-\$8,288	\$4,440	-\$230	-	\$28,402	169,280	-	-	\$24,324	\$120,206
18	-	-\$8,288	\$4,440	-\$1,610	-	\$29,095	168,360	-	-	\$23,637	\$143,843
19	-	-\$8,288	\$4,440	-\$230	-	\$29,804	167,440	-	-	\$25,727	\$169,570
20	-	-\$8,288	\$4,440	-\$20,010	-	\$30,530	166,520	-	-	\$6,672	\$176,242
21	-	-\$8,288	\$4,440	-\$230	-	\$31,272	165,600	-	-	\$27,194	\$203,436
22	-	-\$8,288	\$4,440	-\$1,610	-	\$32,031	164,680	-	-	\$26,573	\$230,010
23	-	-\$8,288	\$4,440	-\$230	-	\$32,808	163,760	-	-	\$28,730	\$258,740
24	-	-\$8,288	\$4,440	-\$1,610	-	\$33,602	162,840	-	-	\$28,144	\$286,884
25	-	-\$8,288	\$4,440	-\$18,630	-	\$34,415	161,920	-	-	\$11,937	\$298,821
26	-	-\$8,288	\$4,440	-\$1,610	-	\$35,246	161,000	-	-	\$29,788	\$328,609
27	-	-\$8,288	\$4,440	-\$230	-	\$36,096	160,080	-	-	\$32,018	\$360,627
28	-	-\$8,288	\$4,440	-\$1,610	-	\$36,965	159,160	-	-	\$31,507	\$392,134
29	-	-\$8,288	\$4,440	-\$230	-	\$37,854	158,240	-	-	\$33,776	\$425,910
30	-	-\$8,288	\$4,440	-\$20,010	-	\$38,763	157,320	-	-	\$14,905	\$440,815
Totals:	-\$232,700	-\$248,625	\$133,190	-\$138,000	\$7,176	\$838,914	5,119,800	\$67,860	\$13,000	\$440,815	-

Inputs & Assumptions	
Project Price	\$232,700
Current Utility Rate (per kWh)	\$0.118/kWh - Total cost of energy divided by total energy consumed
Annual Energy Consumption (kWh)	184,000 kWh
Energy Consumption Inflation Rate	0.0%
Year 1 Energy Savings	\$19,238
System Size	65 kW
Projected Annual Energy Production	184,000 kWh
Utility Inflation Rate	3.0%
System Degradation Rate	0.50%
Investment Tax Credit (ITC)	10% of system value capped at \$2,000/kW turnkey install cost
Effective Federal Tax Rate	30.0%
MACRS Bonus Depreciation Schedule - 2018 only	Year 1 - 52%, Year 2 - 19.2%, Year 3 - 11.52%, Year 4 - 6.91%, Year 5 - 6.91%, Year 6 - 3.46%