Non-Traditional CHP Markets are an Untapped Resource

- Large CHP potential in commercial, institutional, light manufacturing, government and military applications
- Markets utilize smaller systems (< 10MW)
- Markets have limited CHP experience
- Users have limited technical resources
- History of issues with system performance and with CHP sales and service support
- Many perceived risks by both users and suppliers

Interest in CHP is growing in these Markets

Installations and Capacity by Application, 2008-2017

Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2017)
DOE Packaged System CHP eCatalog Program

- Designed to increase deployment of CHP in key markets that have been underdeveloped due to a variety of barriers that increase the perceived risks to both end-users and suppliers.

- These markets are served by smaller systems (generally less than 10 MW), which are conducive to packaging and/or modularization.

**eCatalog focus**

<table>
<thead>
<tr>
<th>Application (no export of electricity)</th>
<th>50-500 kW</th>
<th>0.5 - 1 MW</th>
<th>1 - 5 MW</th>
<th>5 - 10 MW</th>
<th>5 - 20 MW</th>
<th>&gt; 20 MW</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>6,281</td>
<td>4,351</td>
<td>15,567</td>
<td>9,064</td>
<td>7,971</td>
<td>21,157</td>
<td>65,381</td>
</tr>
<tr>
<td>Commercial</td>
<td>20,068</td>
<td>18,100</td>
<td>20,284</td>
<td>5,504</td>
<td>3,948</td>
<td>8,026</td>
<td>75,930</td>
</tr>
<tr>
<td>Total</td>
<td>26,349</td>
<td>22,451</td>
<td>35,470</td>
<td>14,568</td>
<td>11,919</td>
<td>30,183</td>
<td>140,941</td>
</tr>
</tbody>
</table>

Source: US DOE CHP Technical Potential in the US, June 2017
Ultimate Objective is to Promote Self-Sustaining Markets

- Build upon the successful CHP model developed by NYSERDA to reach regional/national markets where CHP value streams will eventually develop into a self-sustaining and robust markets.

Current State

- Market Delivers: 5 – 9 year payback due to under-developed design, sales and installation infrastructure
- Customer Demands: 3 – 4 year payback due to perceived risks

Future State

- Market Delivers: 4 – 5 year payback
- Customer Accepts: 4 – 5 year payback

Reduces risk to customer, and reduce sales, marketing and installation costs for developer
NYSERDA’s Packaged CHP Catalog Program

- NYSERDA Packaged CHP Catalog - Reducing perceived risk of installing and operating CHP by offering comparable standardization of CHP systems and field service agreements.

- Requires single-point-responsibility as the basis for customer-vendor relationship and replicability.

- Ramped-up Approved CHP Vendors and their Approved Packages from launch in 2013 (8 Vendors, 36 packages) to end of 2017 (20 Vendors, 219 packages).
NYSERDA’s Program Impact

- Reduced project implementation timelines (from project approaching NYSERDA to commissioning) by 44%
- Reduced total project costs by 24% ($3,150/kW).

- Increased project uptake in NYSERDA CHP incentive program
U.S. DOE’s Packaged CHP eCatalog
Reducing Risks for End-Users and Vendors

- Combination of web-based Catalog of DOE recognized packaged systems and suppliers, and state/utility partners with CHP market engagement programs is targeted to reduce total project costs and installation times for CHP systems in these markets by 20%.
Reducing Design and Installation Errors

- Creating replicable CHP systems to reduce design errors and limit uncertainty with the associated performance, time, and cost impacts.

Source: Packaged CHP System Catalog – Enrolled Vendor Ally User’s Guide
Fostering Competition

• Expanding CHP product offerings, improving quality, and controlling costs by promoting increased competition.
Reducing Customer Acquisition Costs

- Reducing customer acquisition costs for CHP vendors, and lower costs for the user.
DOE Packaged CHP eCatalog – Key Definitions

- User
- Packager
- Solutions Provider
- Recognized Packaged System
- Customer Engagement Partner
PACKAGED CHP SYSTEMS.
RIGOROUS RECOGNITION PROCESS.

The Packaged Combined Heat and Power Catalog (eCatalog) is a voluntary public/private partnership designed to increase deployment of CHP in commercial, institutional and multi-family buildings and manufacturing plants. The core of the eCatalog are CHP Packages who commit to provide pre-engineered and tested Packaged CHP systems that meet or exceed DOE performance requirements and CHP Solution Providers who commit to provide responsible installation, commissioning, maintenance and service of recognized Packaged CHP systems and also provide a single point of responsibility.

MARKET ENGAGEMENT PROGRAMS: INCENTIVIZING CHP IN YOUR AREA
MAXIMIZE YOUR CHP INVESTMENT WHEN YOU INSTALL QUALIFYING SYSTEMS

State, local and utility programs are designed to remove barriers and or incentivize technologies that improve energy efficiency, reduce electric demand, improve resiliency and/or reduce emissions. CHP systems often qualify for these programs. State and local agencies, as well as utilities with CHP programs that have selected to use the eCatalog an integral part of their program, have entered their locations where their programs are in effect. When you search the eCatalog, using your site ZIP code, the equipment cards will show an icon indicating that the equipment is eligible for a program. Also the specific program entity will appear on the right margin of the equipment detail sheets.
TEMPORA-260-Z15

- **Power Output:** 922 kW
- **Thermal Output:** Hot Water Only
- **Fuel:** Natural Gas
- **Prime Mover:** 3x Reciprocating engine
- **Grid Connection:** Parallel Only

**FULL MATCH (100%)**
MCLAUGHLIN-WIEGAND: TEMPORA-260-Z15

OVERVIEW

PACKAGED CHP SYSTEM HIGHLIGHTS

<table>
<thead>
<tr>
<th>Solution Provider</th>
<th>McLaughlin-Wiegand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>TEMPORA-260-Z15</td>
</tr>
<tr>
<td>Thermal Outputs</td>
<td>Hot Water</td>
</tr>
<tr>
<td>Assurance Plan</td>
<td>Depends on location</td>
</tr>
<tr>
<td>Grid Connection Type</td>
<td>Grid Parallel Only</td>
</tr>
</tbody>
</table>

KEY PERFORMANCE DATA

| CHP Design Efficiency 1   | 50.6%                    |
| Prime Mover              | Reciprocating engines    |
| Number of Prime Movers   | 3                        |
| Net Power Output (kW)    | 222                      |

1. (Net Power Output & Thermal Output) / Energy Input at 25°C and 100% gross power
2. Net Power Output is Gross Prime Mover Power less CHP system penalties, less fuel gas booster if required and less chiller penalties during chiller operation
3. Hot water capacity is usable energy assuming 100% supply and minimum allowable return temperature to the Packaged CHP System

MCLAUGHLIN-WIEGAND | COMPANY DESCRIPTION

Quo us sit et accusantium voluptas tempora voluptates. Doloribus dolorem exceptio quas.

INSTALLATION EXPERIENCE

PERFORMANCE DATA
## PERFORMANCE DATA

<table>
<thead>
<tr>
<th></th>
<th>100% GROSS POWER</th>
<th>75% GROSS POWER</th>
<th>50% GROSS POWER</th>
<th>45% GROSS POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ambient Temperature</strong></td>
<td>95°F 59°F 0°F</td>
<td>95°F 59°F 0°F</td>
<td>95°F 59°F 0°F</td>
<td>95°F 59°F 0°F</td>
</tr>
<tr>
<td><strong>CHP Fuel Input (MMBtu per hour HHV)</strong></td>
<td>14.25 13.75 13.25</td>
<td>10.80 11.00 11.00</td>
<td>7.23 7.61 7.72</td>
<td>6.72 6.69 6.93</td>
</tr>
<tr>
<td><strong>Gross Electricity Output (kW)</strong></td>
<td>1,153 1,076 1,099</td>
<td>1,076 1,162 1,395</td>
<td>856 939 556</td>
<td>525 582 771</td>
</tr>
<tr>
<td><strong>Net Electricity Output (kW)</strong></td>
<td>971 922 900</td>
<td>1,022 1,058 1,397</td>
<td>424 696 491</td>
<td>383 585 585</td>
</tr>
<tr>
<td><strong>Net Electric Efficiency % (HHV)</strong></td>
<td>32.2 29.8 19.8</td>
<td>32.3 30.9 37.2</td>
<td>21.2 20.2 22.9</td>
<td>23.9 24.9 30.7</td>
</tr>
<tr>
<td><strong>Supply Temp to Site (°F)</strong></td>
<td>180 180 180</td>
<td>180 180 180</td>
<td>180 180 180</td>
<td>180 180 180</td>
</tr>
<tr>
<td><strong>Return Temp from Site (°F)</strong></td>
<td>32 78 11</td>
<td>12 2 100</td>
<td>67 3 83</td>
<td>72 95 59</td>
</tr>
<tr>
<td><strong>Hot Water Capacity (MMBtu/hr)</strong></td>
<td>3.05 5.79 5.03</td>
<td>3.56 2.97 2.66</td>
<td>2.50 1.93 2.78</td>
<td>2.73 2.67 2.90</td>
</tr>
<tr>
<td><strong>Thermal Efficiency % (HHV)</strong></td>
<td>27.0 28.0 22.0</td>
<td>23.0 22.0 20.0</td>
<td>22.0 23.0 20.0</td>
<td>20.0 27.0 27.0</td>
</tr>
<tr>
<td><strong>CHP Fuel Use Eff % (Hot Water Operation)</strong></td>
<td>50.2 59.8 51.6</td>
<td>65.3 52.9 61.2</td>
<td>50.2 55.3 60.9</td>
<td>63.9 61.9 71.7</td>
</tr>
<tr>
<td><strong>NOx Emissions without Aftertreatment (lb/MWhe)</strong></td>
<td></td>
<td></td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td><strong>CO2 Emissions without Aftertreatment (lb/MWhe)</strong></td>
<td></td>
<td></td>
<td>82.0</td>
<td></td>
</tr>
<tr>
<td><strong>TVOC Emissions without Aftertreatment (lb/MWhe)</strong></td>
<td></td>
<td></td>
<td>89.0</td>
<td></td>
</tr>
<tr>
<td><strong>Fuel Gas Pressure to Packaged CHP System (psig)</strong></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Fuel Gas Booster Compressor Power Required (kW)</strong></td>
<td>2</td>
<td>29</td>
<td>55</td>
<td>3</td>
</tr>
</tbody>
</table>
### Generator/Interconnection

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>MODEL</th>
<th>TYPE</th>
<th>CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leng-Root</td>
<td>Wise PLC-500</td>
<td>Induction</td>
<td>9 kW</td>
</tr>
<tr>
<td>Donnelly Group</td>
<td>Nelder Group 778</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazier-Haskins</td>
<td>Monta, Vaum and Quitzon 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grenadier Ltd</td>
<td>Zollern/Abraham 227</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emmertch PLC</td>
<td>Runningsdorf and Sons 300</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grid Interconnection: Grid Parallel Only

### Thermal Recovery Systems

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kurze PLC</td>
<td>Schneider-McCuller C22</td>
</tr>
<tr>
<td>Harman-Goodwin</td>
<td>Schroeder, Hagemann and Wexler 978</td>
</tr>
<tr>
<td>Mee LLC</td>
<td>Collin/Wagner 916</td>
</tr>
<tr>
<td>Thiel, Kisslo and Moranen</td>
<td>Jacobs PLC 975</td>
</tr>
<tr>
<td>McGlynn, pages and Roberts</td>
<td>Budridge Inc 984</td>
</tr>
</tbody>
</table>

### Sound

System Sound @ 1m height and 10m distance (dBA): 3.0 dBA

### Footprint

<table>
<thead>
<tr>
<th>PART / COMPONENT</th>
<th>WIDTH IN FEET</th>
<th>LENGTH IN FEET</th>
<th>HEIGHT IN FEET</th>
<th>WEIGHT IN POUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime Mover/Generator system (includes maintenance clearances)</td>
<td>25.0</td>
<td>40.0</td>
<td>93.0</td>
<td>452</td>
</tr>
<tr>
<td>Heat Recovery subsystem if separate (includes maintenance clearances)</td>
<td>78.0</td>
<td>38.0</td>
<td>55.0</td>
<td>47</td>
</tr>
<tr>
<td>Chiller if separate (includes maintenance clearances)</td>
<td>19.0</td>
<td>83.0</td>
<td>12.0</td>
<td>45</td>
</tr>
</tbody>
</table>
eCatalog Program Plan

- **May 2018**
  - Preview with Pilot State CEP

- **July 2018**
  - First Feed Back Revisions

- **August 2018**
  - Preview with Pilot Utility Customer Engagement Programs

- **September – December**
  - Populate pilot site with Packagers, recognized Packages, Solutions Providers and CEPs

- **~ January**
  - Ability to launch the Catalog and recruit additional Packagers, recognized Packages, Solutions Providers and CEPs
The eCatalog alone is not enough – success requires state/utility market engagement programs to promote CHP deployment, publicize the eCatalog, and provide technical and market assistance:

- Incorporate the eCatalog into CHP programs
- Actively engage with vendors, end-users and other stakeholders to promote the program
- Create a “friendly” environment for CHP with streamlined processes
- Improve end-user confidence with performance verification
DOE Packaged CHP Accelerator

• Better Buildings Accelerators demonstrate, catalyze and validate innovative approaches to increase investment in efficient energy technologies.

• Objective - Validate packaged CHP technologies appropriate for commercial, institutional, multi-family, light manufacturing and government (civilian and military)

• CHP Supplier Partners – CHP system packagers and solution providers participating in the national eCatalog of packaged CHP systems

• CHP Engagement Partners – Utilities, federal agencies, states, cities or other market entities committed to promoting packaged CHP (via the eCatalog)
Goals and Expected Outcomes

- Validate the installations and performance of packaged CHP systems nationally
- Analyze the project development time and costs of packaged CHP systems enabled through the eCatalog
- Evaluate the integration of new technologies with packaged CHP systems (hybrid systems)
- Identify R&D challenges and opportunities around packaged CHP and related technologies

The overarching goal of the Packaged CHP Accelerator is to research and validate that total project costs and installation times for packaged CHP systems can be reduced by 20% or more, and that expected performance is achieved through the use of pre-engineered, technically validated systems that reduce risk for both the CHP user and supplier.
## Current Accelerator Partners

### CHP Engagement Partners
- Baltimore Gas and Electric (MD)
- ONE Gas (TX/KS/OK)
- Peoples Gas (Pittsburgh)
- National Grid (NY/MA/RI)
- LIPA/PSEG-LI (Long Island)
- Commonwealth Edison (IL)
- AEP Ohio (OH)
- Maryland Energy Administration (MD)
- Missouri Division of Energy

### CHP Suppliers Partners
- Kraft Power
- 2G Energy
- Stewart and Stevenson Power, Atlantic Division
- GEM Energy
- Martin Energy Group
- GE Distributed Power
- Sterling and Wilson
- Northeast Energy
- Caterpillar
- Capstone Turbine Corp
- Unison Energy
- MacAllister Power Systems
- Centrica Business Solutions
- Aegis Energy Services
Questions

fake.ecatalog.industrialenergytools.com

Bruce Hedman
bhedman.entropyresearch@gmail.com
202-251-0017
DOE Commitment

• Develop and provide support for a national, web-based eCatalog of DOE-validated CHP packaged systems

• Provide tools and resources to the CHP Engagement Partners to assist in the development and installation of packaged CHP

• Provide technical assistance support to CHP Engagement Partners and facility owners/operators through the CHP Technical Assistance Partnerships (CHP TAPs)

• Aggregate and analyze installation, cost, and performance data to validate the benefits provided by packaged CHP systems

• Collect and share best practices and lessons learned

• Facilitate peer-to-peer information exchange

• Provide national recognition to Partners
• Provide feedback to DOE on the technical elements of packaged CHP systems within the eCatalog

• Engage potential CHP customers on applications of packaged CHP systems and use of the eCatalog

• Provide technical and programmatic support to promote packaged CHP to potential end-users

• Coordinate with CHP Supplier Partners to validate packaged CHP installation, cost and performance data

• Document and share lessons learned and best practices
CHP Supplier Partner Commitment

• Become a qualified *eCatalog* CHP Packager or CHP Solution Provider

• Provide feedback to DOE on the technical elements of the *eCatalog* development

• Submit packaged CHP systems for inclusion in the *eCatalog*

• Provide packaged CHP installation validation, which may include data on location, development time, performance and costs

• Identify potential R&D opportunities and emerging packaged CHP technologies and solutions