Five Simple Steps to Immediately Determine Industrial CHP Viability

David C. Oehl, P.E.

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Overview

- Introduction
- Industrial CHP Motivations
- Market Conditions
- Viability Modeling
- Government Initiatives
- The Five Simple Steps
- Takeaways
Introduction

MAVEN POWER

- Equipment & Services for On-site & Distributed Power Generation
- Thermal Power Generation (2-50MW)
- Engineering to Turn-key
- Cogeneration/CHP Projects
  - Prequalification
  - Techno-Economic Feasibility Studies
  - Basic/Detailed Engineering
  - EPC Support
- 5 Simple Steps a result of complex, costly Studies
Industrial CHP Motivations

- Combined Heat & Power (CHP) or Cogeneration
- Traditional Markets
  - Pulp & Paper
  - Bottling, Canneries, Breweries
  - Campuses (Hospitals, Universities)
  - Oil & Gas, Cement, Steel
- Industrial Sector is Large Market
  - 30% of all Consumed Power
Industrial CHP Motivations

- Abundant & Low Cost Natural Gas
  - 120 year supply
  - Explosive new growth
  - Prices still at Historic Lows ($\frac{1}{4} - \frac{1}{6}$ Diesel Price)
  - Clean (2 x coal)

- Spark Spreads Reasonable $\rightarrow$ Trending Higher?

- Aversion to Foreign Energy Sources

- Low Cost, Abundance of Capital

- Governmental & Regulatory Initiatives
Market Conditions

- Electric Prices Stable over Last Several Years (6.5 – 7.5 ¢ per kWh).
- Natural Gas Prices Down ~30% since Jan 2010
- Spark Spread Average more than doubled since early 2010.
  - Single Largest Indicator of CHP Viability
CHP Viability Modeling

- Gas Turbine (1 x 1 configuration)
  - 5.3MWe (CGT)
  - 24,000 pph saturated steam
  - 82% CHP Efficiency
  - 92.5% load factor

- Industrial User
  - Low or no land costs
  - Low cost of money
  - Near all-in analysis
    - Capex, Siting, Financing
    - O&M, Overhauls
    - SCR

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CHP Viability Modeling

5.3MW Cogeneration Plant
Time to Payback for Various Installed Costs
Zero Plant Asset Consideration

<table>
<thead>
<tr>
<th>Installed Cost (USD/kW)</th>
<th>Spark Spread (¢/kWh – USD/MMBtu)</th>
<th>Payback (Years)</th>
</tr>
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<tbody>
<tr>
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<tr>
<td>$1000</td>
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</table>
CHP Viability Modeling

5.3MW Cogeneration Plant
Time to Payback for Various Installed Costs
$1500/kW Plant Asset Consideration

<table>
<thead>
<tr>
<th>Spark Spread (¢/kWh – USD/MMBtu)</th>
<th>Payback (Years)</th>
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<tbody>
<tr>
<td>1.5</td>
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<tr>
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<td>6.33 yrs</td>
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<tr>
<td>2.5</td>
<td>5.42 yrs</td>
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<tr>
<td>3</td>
<td>4.52 yrs</td>
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<tr>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Installed Cost (USD/kW)
- 0% Asset Value
- 30% Asset Value
- 40% Asset Value
- 50% Asset Value
Government & Regulatory Initiatives

- Executive Order “Accelerating Investment in Industrial Energy Efficiency”
  - 40GW of NEW Industrial CHP by 2020
  - Workshops to review investing models and barriers to CHP
  - Incentives for deploying CHP
    - Emissions Trading Programs
    - Grants & Loans
    - Compliance Options which recognize emissions benefits of CHP.
Government & Regulatory Initiatives

● State Level – Texas
  – TCEQ (TX Commission on Environmental Quality) Permit by Rule 106.513
  – Cuts red tape associated with Environmental Air Permits
  – Two Industrial CHP Size Ranges
    • Up to 8MWe
    • Up to 15MWe
Government & Regulatory Initiatives

- State Level – Texas

<table>
<thead>
<tr>
<th>Plant Size Range (1 Unit or Combination)</th>
<th>Emission Type</th>
<th>Emission Limit (lb/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20kw to 8MW</td>
<td>NO\textsubscript{x}</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>CO</td>
<td>9.0</td>
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<tr>
<td>8MW to 15MW\textsuperscript{1}</td>
<td>NO\textsubscript{x}</td>
<td>0.7</td>
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<tr>
<td></td>
<td>CO</td>
<td>9.0</td>
</tr>
</tbody>
</table>

Table 1. TCEQ Permit by Rule Emissions Limits

- Values DO NOT include CHP credit of 1MW per 3.4MMBtu of Recovered Heat
- Some Standard Industrial DLE Turbine Units Qualify, Unmodified

\textsuperscript{1}CHP Plants in this size range require an oxidation catalyst device to ensure compliance with NAAQS PM\textsubscript{2.5} requirements.
Government & Regulatory Initiatives

5.0 MWe Example Calculation - Texas PBR

NOx = 5.8 lb/h, for one hour --> 5.8 lb NOx
5.8/5.0 MWe = 1.16 lb/MWh (FAILS the 1.0 lb/MWh NOx requirement)

Exhaust Heat = 24.1 MMBtu/hr. Assume 80% HRSG efficiency and 25% recovery² → 24.1 x 0.8 x 0.25 = 4.82 MMBtu/hr

Credit → 1 MWh per 3.4 MMBtu
4.82/3.4 = 1.41

So, 5.0 + 1.41 = 6.41 MWe
New, Adjusted Requirement = 6.41 / 5.0 = 1.283 lb/MWh
1.16 lb/MWh now PASSES the NOx requirement (1.16 < 1.283)

²PBR requires a minimum of 20% heat recovery to qualify.
The Five Simple Steps to Determine Industrial CHP Viability
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1. **Power & Natural Gas Source**
   - Currently purchasing natural gas & kWh’s from external supplier
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   - Steam Consumption >= 50% of Capacity
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5. **Capacity Factor >= 60%:**
The Five Simple Steps to Determine Industrial CHP Viability

1. Five Steps based on dozens of studies and executed projects.

2. Viability Defined?
   - Simple payback period used
   - Could use IRR, Cash Flow, Reliability Criteria

3. Sufficient but not Necessary for Feasible Project
   - Electrical Load < 5MW?
   - Steam Load < 50% Capacity?
   - Dramatic Capacity Factor Changes (Seasonal, Operational)?
Takeaways

● Industrial CHP continues to be attractive
  – Reasonable payback periods
  – Energy availability

● Worst Case scenario presented:
  – Single Unit, Small kWh & pph requirements
  – No subsidies or other gov’t support

● 5 Simple Steps an easy pre-qualifier:
  – Good indicator prior to definitive feasibility studies
  – Helps determine plant size and energy requirements
  – Consider kWh, kW/kVAR demand and demand credits in a hybrid for the spark spread criteria.
Takeaways

- Industrial CHP doesn’t have to be a large Capital Expenditure consideration for end user.
  - Abundance of money on the sidelines
  - 3rd Party BOO projects could reduce power costs by 15% or more.
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