Feasibility Study for the Integration of Trigeneration for The New Independence High School/Shared Use Facility

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Mechanical Option
Introduction

- Background
- The Problem
- Proposed Solution
- Results and Conclusions
Project Background

- Location – Independence, Ohio
- 114,330 sqft Secondary Education & Community Use Facility
- Funded through public bonds
- Total Project Cost – $33 million
Project Background - Who

- Project Team Owners:
  - City of Independence (property)
  - Independence Schools District (facility)

- Project Design Professionals:
  - Sear-Brown (S,A,S,M,E)
  - Then Design Architects Ltd (Interiors)

- Project Constructors:
  - Turner Construction (CM)
  - 22 Multiple Prime Contractors
Project Background - Site
Project Background

Plan
Project Background

- Plan

A Different Viewpoint

- Building as an inefficient fossil fuel energy consumer
- Building as environment polluter
Typical building fuel energy sources

- **Electricity**
  - Coal Combustion
  - Nuclear
  - Hydrology/Wind Misc
- **Thermal Energy**
  - Natural Gas Combustion
  - Fuel Oil Combustion
The Problem

Building Energy Production Efficiency

- **Thermal energy**
  - 80%-95% equipment efficiency
  - 1%-2% system losses
    - 79%-94% thermal energy available for building

- **Electric Energy**
  - 34% generation efficiency
  - 2% Transmission and transformer losses
    - 32% electric energy available for building

Source: Energy Information Administration
National Energy Production
Pollution Emissions

- **979** Metric tons CO₂
- **4.7 Million** tons NOₓ
- **9.9 Million** tons SO₂

Source: Energy Information Administration

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**Figure 116. Carbon dioxide emissions from the electric power sector by fuel, 1990-2025 (million metric tons)**

- Coal: 3,299
- Natural gas: 2,571
- Petroleum: 2,322
- 1,795

**Figure 119. Sulfur dioxide emissions from electricity generation, 1990-2025 (million tons)**

- History: 15.9, 12.1, 10.6, 10.2, 9.9, 9.0, 9.0
- Projections: 10.2, 9.9, 9.0, 9.0

**Figure 120. Nitrogen oxide emissions from electricity generation, 1990-2025 (million tons)**

- History: 6.7, 6.4, 4.7, 3.3, 3.5, 3.6, 3.8
- Projections: 6.7, 6.4, 4.7, 3.3, 3.5, 3.6, 3.8
Reasons to Consider Alternate Energy Production/Consumption Strategies

- No New Generation power plants for 10-15 years
- Utilities indicate the need for new transmission infrastructure
  - 2003 Blackout
  - Brownouts

Source: 2001 Bush Administration National Energy Policy
Reasons to Consider Alternate Energy
Production/Consumption Strategies

- Continued need to reduce environment air pollution
- Less dependence on national grid
  - Few generating plants make great terrorist targets
Reasons to Consider Alternate Energy Production/Consumption Strategies

- Former Vice President of ASHRAE, Mr. Peterson set the goal:
  - “…. Zero energy [buildings] by 2020.”
Proposed Redesign Goals

- Reduce building total fossil fuel energy consumption
- Reduce total environment emissions
- Increase building energy operating efficiency
  - Defined as
    - Total Energy Output (Elec & Thermal)
    - Total Energy Input (Fuel Source)
Proposed Solution - Trigeneration

- Evolution of cogeneration
  - Conversion of one chemical energy fuel source into 2 primary alternate energy forms
    - Electricity
    - Hot Water or Steam

- Trigeneration
  - Conversion of thermal primary energy into 1 secondary alternate energy form.
    - Chilled Water
Cogeneration Equipment

- Microturbines
  - Combustion Turbine Engines
    - Multiple fuel sources, typically Natural Gas
      - natural gas
    - Higher reliability, lower maintenance

- Reciprocating Engines
  - Multiple fuel sources, typically Natural Gas
    - natural gas
  - High reliability, higher maintenance, higher thermal output
Proposed Solution - Trigeneration

- Natural Gas
- Engine or Turbine
- Generator
- Heat Recovery Unit
- Process Loads
- Electric Chillers
- Absorption Chillers
- Steam or Hot Water
- Air Handler
- Cooling / Heating
- Building or Facility
- Electricity

Diagram showing the integration of natural gas through an engine or turbine, generating heat and electricity, which are then used to power a heat recovery unit, process loads, and absorbent chillers. The resulting steam or hot water powers an air handler, which provides cooling/heating to the building or facility.
Proposed Solution - Trigeneration

http://www.hessmicrogen.com/products/how_cogen.html#

Trigeneration Design Strategies

- Independent power/thermal production:
  - Electric Utility on Standby (automatic transfer switch)

- Excess electric & thermal production
  - Sell excess electric back to utility
  - Use excess thermal for district heating/cooling needs

- Load Shaving
  - Interconnection with electric Utility
Existing Building Operating Conditions

YEARLY WEEKDAY KW DEMAND

Elliot Unit
Base Load

Hess Microgen Unit

Existing Building Operating Conditions

YEARLY WEEKDAY THERMAL DEMAND

- Elliot Unit
- Base Load
- Hess Microgen Unit

- JAN TOTAL THERMAL MBH WKDY
- FEB TOTAL THERMAL MBH WKDY
- MAR TOTAL THERMAL MBH WKDY
- APR TOTAL THERMAL MBH WKDY
- MAY TOTAL THERMAL MBH WKDY
- JUN TOTAL THERMAL MBH WKDY
- JUL TOTAL THERMAL MBH WKDY
- AUG TOTAL THERMAL MBH WKDY
- SEP TOTAL THERMAL MBH WKDY
- OCT TOTAL THERMAL MBH WKDY
- NOV TOTAL THERMAL MBH WKDY
- DEC TOTAL THERMAL MBH WKDY
Proposed Trigeneration

- Replace 1 chiller with HW absorption chiller using HW from Cogeneration Equipment
- Replace All Hot Water Boilers except two for backup extra hw production for chiller
- VFD Primary/Secondary Pumping Remains
- Interconnect power production with building electric distribution
Proposed Equipment

- ** Proposed Equipment Base load 
  - Elliot Model 100
  - 100Kw output w/ 0.8 lead/lag PF correction
  - 587Mbh Thermal output
  - 75% Equipment efficiency

- ** Proposed Equipment Occupied load 
  - HessModel 375
  - 375Kw output w/ 0.8 lead/lag PF correction
  - 1900Mbh Thermal output
  - 83% Equipment efficiency
Proposed Equipment

- Proposed Cooling Equipment
  - Cention HW absorption Chiller Model 350
Electric Interconnection

- Governed by IEEE standard 1547
- Electric utility companies
Electrical Interconnection

Relaying required

- 50/51 overcurrent
- 81 over/under freq
- 67 reverse power relay
- 37 under power relay
- 27/59 under/over volt
- 25 Synchronism check relay

Breaker/Relays

Can use a switch and fuse instead of a breaker

Transformer

kWh in

Utility

Owner

Loads

No neutral resistor can be installed in the generator

Cogen Units

Breaker/Relays
Constructability Issues

- 16-18 week equipment Lead Times
- 8ftx5ft equipment Footprint
  - Can reuse boiler battery location, combustion air and exhaust ducts
- Sound output level no louder than a typical central station airhandler (75db)
- Weigh on the order of 10,000lbs for the footprint
Maintenance Issues

- Relatively intense regularly scheduled maintenance
  - Typically by contract with MFR OR trained contractor/maintenance staff
  - Down times minimal
  - Refer to report for detailed maintenance schedules/tasks
## Energy, Emissions, & Cost Summary

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<th>ITEM</th>
<th>EXISTING</th>
<th>PROPOSED</th>
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<td>Max Therm/hr Demand Weekday</td>
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<td>1,691,194</td>
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<tr>
<td>Max Kwh demand Weekday typ</td>
<td>1,691,194</td>
<td>1,691,194</td>
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<tr>
<td>Max Kw demand Weekday typ</td>
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<td>475 variable with load</td>
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<td>Particulates</td>
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<td>2,514,120 lbs</td>
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<td>COSTS</td>
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<td>First Costs</td>
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<td>Annual Maint. Costs</td>
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<td>Annual Electric Costs</td>
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<td>$ small amount for Design Day</td>
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<td>Annual Nat Gas Costs</td>
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<td>TOTAL</td>
<td>$ 633,555</td>
<td>$ 1,334,714</td>
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Conclusions/Comments

- Reduced dependence on the National Electric Grid
- Converted the combusted fossil fuel energy into alternate energy forms more efficiently
- Reduced environment air pollution
Conclusions/Comments

- More expensive for equipment and maintenance, HOWEVER
- Federal State grants are available
- Natural Gas companies sometimes offer reduced prices
- Is a growing market
- Manufacturers are increasing
- Displaces the national electric grid demand and thus future increased electric prices
Conclusions/Comments

- Using this strategy in conjunction with:
  - DOAS/Radiant Heating/Cooling
  - Daylighting
  - Variable Frequency Drive
- We might reach the Zero Energy buildings goal since we produce the energy at the building
QUESTIONS