Building Trigeneration Integration Feasibility Study

John Shaw
Mechanical Option
Introduction

- Project Background
- Mechanical Component
- Electrical Component
- Construction Component
Project Background - Where

- Location – Independence, Ohio
Project Background - Who

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

- Project Team Design Professionals:
  - Sear-Brown
    - Site
    - Architecture
    - Structural
    - Mechanical
    - Electrical
  - Then Design Architects Ltd
    - Interiors
  - RCU Architects Inc
Project Background - Who

- Project Team Contractors:
  - Turner Construction
    - Project Construction Management
  - 22 Multiple Prime Contractors
Project Background - What

- Site
Project Background - What

- Elevations
Project Background - What

- Plan

[Diagram of Independence High School layout]

KEY:
- Academic
- Cafeteria
- Circulation
- Sports Facilities
- Media Center
- Entry Plaza

Project Background - What

Plan

Project Background - Why

- Need for new, modern facility
  - Increase modern education opportunities for students
- Local population growth
- Others
Project Background - How

- Funded Through
- Total Project Costs
  - a
- Others
Proposed Redesign Goals

- Reduce building total energy consumption
- Reduce total environment emissions
- Increase building energy operating efficiency
  - Defined as
    - Total Energy Output (Elec & Thermal)
    - Total Energy Input (Fuel Source)
Mechanical/Electrical Component

- Typical building energy sources
  - Electric utility grid connection
  - Combusted fuel source
    - Steam
    - Hot water
    - Utility Power
Mechanical/Electrical Component

- National educational building energy consumption

![Energy Consumption Pie Chart]

Source: Energy Information Administration, 1995 Commercial Buildings Energy Consumption Survey
Mechanical/Electrical Component

- National educational building energy consumption

SITE ENERGY USE IN EDUCATION BUILDINGS 614 trillion Btu

- Space Heating 254 trillion Btu (41%)
- Lighting 122 trillion Btu (20%)
- Water Heating 134 trillion Btu (22%)
- Cooling 37 trillion Btu (6%)
- Other 65 trillion Btu (11%)

Electricity 221 trillion Btu (36%)
- Natural Gas 245 trillion Btu (40%)
- Fuel Oil 57 trillion Btu (15%)
- District Heat 91 trillion Btu (9%)


* Other includes miscellaneous uses (22 trillion Btu), ventilation (13 trillion Btu), cooking (11 trillion Btu), office equipment (11 trillion Btu) and refrigeration (8 trillion Btu).

Note: Due to rounding, individual figures may not sum to totals.
Mechanical/Electrical Component

- National educational building energy consumption

**Natural Gas Consumption per Square Foot (cubic feet)**

- Food Service
- Health Care
- Other
- Lodging
- Public Assembly
- Retail and Service
- Public Order and Safety
- Food Sales
- Education
- Vacant
- Office
- Religious Worship
- Warehouse

Average for all commercial buildings: 99.7 cubic feet per square foot


**NATURAL GAS USE IN EDUCATION BUILDINGS**

- Space Heating 144 billion cu. ft.
- Water Heating 71 billion cu. ft.
- Cooking 9 billion cu. ft.
- Other 15 billion cu. ft.

*Other includes cooling.

National educational building energy consumption

- Average for all commercial buildings: 13.4 kWh per square foot

Source: Energy Information Administration, 1995 Commercial Buildings Energy Consumption Survey

SITE ELECTRICITY USE IN EDUCATION BUILDINGS
- 65 billion kWh

- Lighting: 36 billion kWh (56%)
- Cooling: 10 billion kWh (16%)
- Space Heating: 4 billion kWh (6%)
- Office Equipment: 3 billion kWh (6%)
- Other: 7 billion kWh (11%)

* Other includes miscellaneous uses (2 billion kWh), water heating (2 billion kWh), refrigeration (2 billion kWh), and cooking (1 billion kWh).

Source: Energy Information Administration, 1995 Commercial Buildings Energy Consumption Survey
Mechanical/Electrical Component

- National educational building energy pollution emissions
  – Insert info
Mechanical Component

- Existing HVAC
  - Governed by the Ohio School Facilities Commission
  - 4 general systems – VAV w/HW Reheat
Mechanical Component

- Existing Mechanical Energy Plant
  - (2) 350ton (nominal), Air-Cooled, Rotary Screw Chillers
  - VFD Primary/Secondary Pumping
  - (2) Batteries of 11 & 3, Multi-stage, Natural Gas Fired, Hot Water Boilers
  - VFD Primary/Secondary Pumping

- Need Diagram
Electrical Component

- Existing Electrical Schematic
  - 1000KV primary feed to Building transformer
  - ?kw/?kva transformer.
  - 480V/3phase secondary feed to Building main switchgear
Electrical Component

- Existing Electrical Schematic
- ? Need Diagram
Mechanical/Electrical Component

- Existing Thermal Demand-Design
- INSERT GRAPHIC
Mechanical/Electrical Component

- Existing Electric Demand - Design
- INSERT GRAPHIC
Mechanical/Electrical Component

- Existing Thermal Demand - Weekday
- INSERT GRAPHIC
Mechanical/Electrical Component

- Existing Electric Demand - Weekday
- INSERT GRAPHIC
Mechanical/Electrical Component

- Existing Thermal Demand - Saturday
- INSERT GRAPHIC
Mechanical/Electrical Component

- Existing Electrical Demand - Saturday
- INSERT GRAPHIC
Mechanical/Electrical Component

- Existing Thermal Demand - Sunday
- INSERT GRAPHIC
Mechanical/Electrical Component

- Existing Electric Demand - Sunday
- INSERT GRAPHIC
## Mechanical/Electrical Component

### Existing Energy Consumption

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<th>Component</th>
<th>Value</th>
<th>Unit</th>
<th>Description</th>
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<td>Kwh</td>
<td>On-Pk</td>
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<td></td>
<td>69,511</td>
<td>Kwh</td>
<td>Off-Pk</td>
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<td></td>
<td>926</td>
<td>Kw</td>
<td>On-Pk Dmd</td>
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<tr>
<td>Nat Gas</td>
<td>28,116</td>
<td>Therms</td>
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<td>47</td>
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<td>On-Pk Dmd</td>
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## Mechanical/Electrical Component

- **Existing Energy Consumption Costs**

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## Mechanical/Electrical Component

- **Existing Energy Pollution Emissions**

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What is Trigeneration

- Combustion of fuel source
  - Microturbine (combustion turbine engine)
  - Recipricating Engine
- Conversion of combustion energy
  - Electric
  - Thermal energy (HW or Steam)
- Use of Thermal energy
  - Heating
  - Humidification
  - Cooling
Mechanical/Electrical Component

- Typical building energy sources
  - Electric utility grid connection
  - Combusted fuel source
    - Steam
    - Hot water
    - Trigeneration
Proposed Trigeneration

- Replace 1 chiller with HW absorption chiller using HW from Cogeneration Equipment
- VFD Primary/Secondary Pumping Remains
- Replace All Hot Water Boilers except one for backup
- VFD Primary/Secondary Pumping Remains
- Interconnect power production with building/utility grid
Mechanical/Electrical Component

- Proposed Cooling/Heating Plant Schematic
- GRAPHIC
Mechanical/Electrical Component

- Electric Inter-Connection
- Governed by
- INSERT
Mechanical/Electrical Component

- Proposed Equipment Base load
  - Elliot Model?
  - 100Kw output w/ 0.8 lead/lag PF
  - 587Mbh Thermal output
  - Equipment efficiency
Mechanical/Electrical Component

- GRAPHIC
- PHOTO
Mechanical/Electrical Component

- Proposed Equipment Standard load
  - HessModel
  - 375Kw output w/ 0.8 lead/lag PF
  - 1900Mbh Thermal output
  - Equipment efficiency
Mechanical/Electrical Component

- GRAPHIC
- PHOTO
Proposed Equipment Design

- HessModel?
- 375Kw output w/ 0.8 lead/lag PF
- 1900Mbh Thermal output
- Equipment efficiency
Mechanical/Electrical Component

- GRAPHIC
- PHOTO
Mechanical/Electrical Component

- Proposed Cooling Equipment
  - Cention HW Chiller Model?
  - Performance
Mechanical/Electrical Component

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## Mechanical/Electrical Component

- Probable Fuel Energy Displacement

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## Mechanical/Electrical Component

- Probable Fuel Energy Emissions

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## Probable Fuel Energy Summary

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## Construction Component

- **Htg/Clg/Elec Plant Costs**

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Construction Component

- Payback by Trigeneration
Construction Component

- Operating/Maintenance Costs of Existing Plant
  - Cost
- Operating/Maintenance Cost w/ Cogen
  - Cost
Construction Component

● Maintenance Issues
   – List
Construction Component

Construction Issues
- Equipment Lead Times
- Equipment Footprint
- Sound output level
Conclusions/Comments

- Why Use
  - List
Conclusions/Comments

- Issues to be aware of
  - List