The SCRIPPS Research Institute
Florida Atlantic University

# BIOMEDICAL RESEARCH BUILDING

JUPITER, FLORIDA


PRESENTED BY:

ADAM HOUCK

CONSTRUTION MANAGEMENT OPTION


MONDAY, APRIL 13, 2009

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## presentation OUTLINE

- PROJECT OVERVIEW
- TECHNICAL ANALYSES
  - *ANALYSIS ONE* – Prefabrication of Lab Island Rough-in
  - *ANALYSIS TWO* – Co-Generation – *Mechanical & Electrical Breadth*
  - *ANALYSIS THREE* – Alternate Forming Methods
- INDUSTRY RESEARCH OF BIM & PREFABRICATION
- ACKNOWLEDGEMENTS
- QUESTIONS & COMMENTS

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## JUPITER FLORIDA

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# project OVERVIEW

**PROJECT LOCATION AND SIZE**
Jupiter Florida, Florida Atlantic University Jupiter Campus

**OCCUPANCY AND FUNCTION**
The SCRIPPS Research Institute – Biomedical Research

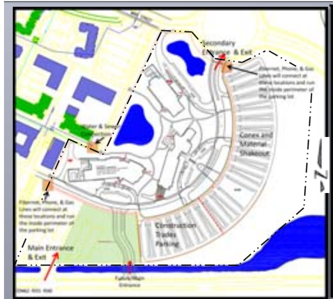
**SIZE**
132,675 GSF

**Construction SCHEDULE**
August 2006 – January 2009

**CONTRACT SIZE** *$358.25/SF*
$47.53 M GMP

# project SITE

## Large Site with 2 Main Entrance/Exits
## Material Staging & Traffic Flow not Issues on this Site

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# project OVERVIEW

## project TEAM

OWNER
**SCRIPPS**

ARCHITECT – *Joint Venture*
**Zeidler Partnership Ltd. & Bohlin Cywinski Jackson**

CONSTRUCTION MANAGER
**FLUOR**

GENERAL CONTRACTOR
**WEITZ - DPR**

# project SITE

Large Site with 2 Main Entrance/Exits
Material Staging & Traffic Flow not Issues on this Site


**THE SCRIPPS RESEARCH INSTITUTE**
**JUPITER FLORIDA**


# project OVERVIEW

## project FEATURES

***1st Floor***
***Vivarium , CUP, Loading Dock, Mechanical Yard***

***2nd & 3rd Floors***
***Research Laboratories, Offices, Common Area***

***3 Story Atrium at the Main Entrance***

***4th Floor***
***Mechanical Penthouse***





# presentation OUTLINE

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# analysis ONE

## Prefabrication of Lab Island Mechanical Rough-in



**FUNCTION**
Laboratory
Work Stations

**PROPOSAL**
Change the installation to a
Prefabricated Assembly

**AS- INSTALLED**
Field Installed by:
*Casework Installer*
*Plumbing Contractor*
*Electrical Contractor*

**GOALS**
Improve Constructability
Schedule Compression
Cost Savings

# prefabrication ANALYSIS

## Prefabrication of Lab Island Assemblies


## prefabrication ANALYSIS

### Prefabrication of Lab Island Assemblies


## analysis ONE

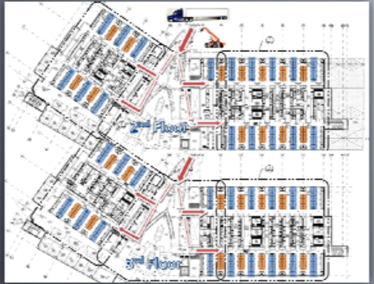
### DESIGN methodology

- Review the Installation Process
  - # of Islands in Laboratory Areas
  - Components of Each Assembly
  - Analyze the Schedule of the Installation
- Design
  - Model Islands in Revit MEP 2009
  - Create Inventory for Each Island
- Estimate
  - Durations & Cost for Both Methods of Installation

## prefabrication ANALYSIS

# prefabrication ANALYSIS

## Prefabrication of Lab Island Assemblies




# analysis RESULTS

## Cost & Schedule

| Field Installed System | |
| --- | --- |
| Materials | $72,906.82 |
| Field Installation | $94,817.73 |
| TOTAL | $167,724.55 |

| Prefabricated System | |
| --- | --- |
| Materials | $72,906.82 |
| Prefabrication | $55,580.90 |
| Field Installation | $2170.00 |
| TOTAL | $130,658.74 |

**Savings of $37,000**

| With Prefabrication | Days to Install | Total Days |
| --- | --- | --- |
| Install 3rd Floor Island Assemblies | 1 | 2 |
| Install 2nd Floor Island Assemblies | 1 | |
| **Without Prefabrication** | | |
| Island Casework Supports 3rd Floor Research One | 5 | 60 |
| Island Piping & Conduit 3rd Floor Research One | 10 | |
| Island Casework Supports 3rd Floor Research Two | 5 | |
| Island Piping & Conduit 3rd Floor Research Two | 10 | |
| Island Casework Supports 2nd Floor Research One | 5 | |
| Island Piping & Conduit 2nd Floor Research One | 10 | |
| Island Casework Supports 2nd Floor Research Two | 5 | |
| Island Piping & Conduit 2nd Floor Research Two | 10 | |

**Savings of 58 Days**

# prefabrication ANALYSIS

## Prefabrication of Lab Island Assemblies

- Prefabrication Saves $0.29/SF
  - Controlled Environment & Learning Curve
  - Inventory from the Model Takeoff
- Cost Comparison
  - Installation Cost only Consideration for Field Installation
    - 0.5 Hours/Island * 2 Men * $35/hour * 62 Islands
  - Lull & Driver Already Provided by Installer
- Productivity

| Crew | #Men | Task | Productivity |
| --- | --- | --- | --- |
| Unload Truck To Lull | 2 | Unload Delivery to Lull | 10 min/4 assemblies |
| Lull Driver | 1 | Lift Assemblies to Bldg. | 10 min/4 assemblies |
| Unload Lull in Bldg. | 2 | Unload Lull inside Bldg & Deliver to Bolt Crew | 5 min/4 assemblies |
| Bolt Crews | 2 | Install Island Assembly – Bolt Into Place | 30 min/assembly |

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# analysis TWO

## Co-Generation plant

BACKGROUND

FPL supplies the campus with its power

PROPOSAL

Add Co-Generation plant to supply the building needs

GOALS

Reduce Electrical Demand of the Building

Produce Electrical, Heating & Cooling Demands of the Building

Reduction of Carbon Footprint

Mitigate Up-Front Investment Through Payback & Savings Analysis

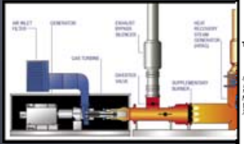
# Mechanical & Electrical ANALYSIS

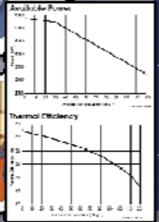
## Co-Generation Plant Addition

# Mechanical & Electrical ANALYSIS

**Solar Turbines**
*A Caterpillar Company*

## Product Selection




HEAT RECOVERY PERFORMANCE DATA

| Specific Site Performance | Saturn 20 | Centaur 40 | Centaur 50 | Mercury 50 |
|---|---|---|---|---|
| Exhaust Temperature, °C | 511 | 446 | 513 | 377 |
| Exhaust Temperature, (°F) | (952) | (835) | (956) | (710) |
| Exhaust Mass Flow, thousand kg/hr | 23.4 | 67.9 | 68.2 | 63.7 |
| Exhaust Mass Flow, (thousand lbs/hr) | (51.5) | (149.6) | (150.3) | (140.4) |
| Turbine Fuel Input, GJ/hr | 17.7 | 45.1 | 56.0 | 42.7 |
| Turbine Fuel Input, (MMBtu/hr) | (16.8) | (42.7) | (53.1) | (40.5) |
| **Process Steam Production (Unfired)** | | | | |
| Steam Output, tonnes/hr | 4.0 | 8.9 | 11.5 | 6.3 |
| Steam Output, (thousand lbs/hr) | (8.9) | (19.6) | (25.3) | (13.8) |
| **Process Steam Production with Supplemental Firing, 871°C (1600°F)** | | | | |
| Steam Output, tonnes/hr | 8.4 | 24.2 | 24.0 | 22.4 |
| Steam Output, (thousand lbs/hr) | (18.5) | (53.3) | (53.0) | (49.4) |
| Additional Fuel to Burner, GJ/hr | 10.4 | 35.7 | 30.5 | 38.7 |
| Additional Fuel to Burner, (MMBtu/hr) | (9.9) | (33.8) | (28.9) | (36.7) |
| **Process Steam Production with Supplemental Firing, 1538°C (2800°F)** | | | | |
| Steam Output, tonnes/hr | 18.1 | 51.3 | 51.0 | 47.4 |
| Steam Output, (thousand lbs/hr) | (40.0) | (113.2) | (112.4) | (104.4) |
| Additional Fuel to Burner, GJ/hr | 33.2 | 100.4 | 95.9 | 100.0 |
| Additional Fuel to Burner, (MMBtu/hr) | (31.5) | (95.2) | (90.9) | (94.8) |

# analysis TWO

## DESIGN methodology

### As-Designed Building Loads

| Thermal Loads | |
|---|---|
| 2 Hot Water Boilers | 7,300 MBH |
| 2 Steam Boilers | 12,500MBH |
| 2 Chillers | 1,300Tons |

| Electrical Loads | |
|---|---|
| Electrical Load | 5.67MW |

| Thermal/Electric Ratio | |
|---|---|
| $\frac{21{,}440{,}000 \frac{BTU}{hr}}{19{,}359{,}688 \frac{BTU}{hr}}$ | 1.107 |

### Sizing Design Conditions for Intake Air Cooling

**Outdoor Air Design Conditions**

- 95°F @60%RH
  $T_{dp} \cong 78°F$
  $w = 0.022$

**Desired Supply Air Conditions**

- $\dot{V}$=30,000 *cfm* ⇨ @ 60°db 80%RH
  $\dot{m}=2.300\frac{BTU}{min}$ $h=24\frac{BTU}{lbm}$ $w=0.009\frac{lbm\ H_2O}{lbm\ air}$
  $\rho=13.1\frac{ft^3}{lbm}$

### Utility Information

Customer Charge – **$375.00/Month**

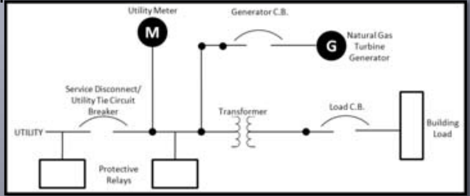
| | ON – PEAK | CHARGES | OFF – PEAK | |
|---|---|---|---|---|
| | $0.00634/kW | BASE | $0.00508/kW | |
| | $0.05928/kW | NRG | $0.05432/kW | |
| | $0.00071/kW | Environmental | $0.00071/kW | |
| | $0.00012/kW | Storm | $0.00012/kW | |
| $0.06805/kW | $0.00160/kW | Conservation | $0.00160/kW | $0.06183/kW |
| | $5.90000/kW | Demand | $5.90000/kW | |
| | $3.08000/kW | Capacity | $3.08000/kW | |

*The 1st Boxed # is the amount we will be paid by the utility for power supplied back to the grid, the 2nd boxed # is the amount we will be paid by the grid for having power available whenever they need it.*

# Mechanical & Electrical ANALYSIS

## Product Selection

- FEEDERS
  - 23kV & 150 Amp Transmission From Turbine
  - MV Cable 90°C [3] #1 AWG rated for 175 Amps
  - 150 Amp Fuse to Protect



# Mechanical & Electrical ANALYSIS

## Cost Comparison

| Original System | |
|---|---|
| [2] 5400 MBH $H_2O$ Boilers | $75,000 |
| [2] 8000 MBH Steam Boilers | $145,000 |
| [2] 1050 Ton Centrifugal Chillers | $1,026,000 |
| [1] 2.25MW Generator | $703,407 |
| *TOTAL* | $1,949,407 |

**Up-Front Investment**
**$5.06 Million**
***$38.13/SF***

| Cogeneration System | |
|---|---|
| [2] 1000 Ton Absorption Chillers | $1,040,000 |
| [1] 1000 Ton Centrifugal Chiller | $370,000 |
| [1] 200 kW Black Start Generator | $120,000 |
| [1] Mercury 50 Gas Turbine(23kV) | $4,000,000 |
| [1] 5.5 MW Switchgear w/ Turbine | |
| [1] Big Duct Burner | $300,000 |
| [1]Power Disconnect 5.5MW 23kV | $43,000 |
| [1] Steam ⇨ $H_2O$ Heat Xchanger (10,000,000 $^{btu}/_{hr}$) | $35,000 |
| [2] Steam Turbines ([1]100kW & [1]500kW) | $1,100,000 |
| *TOTAL* | $7,008,000 |

# analysis RESULTS

## Design IMPACT



**Electrical Supply Requirements**
- 4.952 MW

Originally 5.67 MW

**Electrical Supply Capacity**
- 5.2 MW

Turbine & pressure reducing Steam Turbines

**Steam Supply Requirements**
- 56,500 PPH

**Steam Supply Capacity**
- 104,400 PPH

- **Produce All Electricity On Site with Turbine**
  - eliminate grid dependence
- **Produce All Steam, Cooling & HW Requirements with Turbine**
  - Cooling done utilizing Absorption Chillers run by steam from turbine

# Mechanical & Electrical ANALYSIS

## Utility Billing Information For 3 Building TSRI Campus

*Utility and Gas Billing for 1yr. Period*

| Days | Month-yr of Service | Bldg $ | Bldg KWH | Chiller $ | Chiller KWH | TECO GAS Supplier | Therms N Gas |
|---|---|---|---|---|---|---|---|
| 30 | Apr-07 | $30,000.00 | 320000 | $24,000.00 | 227600 | $13,748.15 | 15622.9 |
| 31 | May-07 | $31,000.00 | 334000 | $34,000.00 | 343600 | $12,205.34 | 13869.7 |
| 30 | Jun-07 | $34,000.00 | 371600 | $42,000.00 | 447200 | $12,260.95 | 13932.9 |
| 31 | Jul-07 | $34,000.00 | 366400 | $44,000.00 | 465200 | $9,374.02 | 10652.3 |
| 31 | Aug-07 | $33,000.00 | 352800 | $44,000.00 | 464400 | $9,749.78 | 11079.3 |
| 30 | Sep-07 | $36,000.00 | 389600 | $46,000.00 | 490400 | $8,648.73 | 9828.1 |
| 31 | Oct-07 | $32,000.00 | 345600 | $37,000.00 | 393200 | $8,990.70 | 10216.7 |
| 30 | Nov-07 | $36,000.00 | 390000 | $30,000.00 | 304000 | $11,704.09 | 13300.1 |
| 31 | Dec-07 | $34,000.00 | 364800 | $28,000.00 | 288400 | $12,829.34 | 14578.8 |
| **275** | **SubTotal** | **$300,000.00** | **3234800** | **$329,000.00** | **3424000** | **$99,511.10** | **113080.8** |
| 31 | Jan-08 | $36,000.00 | 393800 | $24,000.00 | 239600 | $14,017.26 | 15928.7 |
| 28 | Feb-08 | $32,000.00 | 348400 | $30,000.00 | 311600 | $13,158.73 | 14953.1 |
| 31 | Mar-08 | $32,000.00 | 348400 | $29,000.00 | 284400 | $14,496.50 | 16473.3 |
| **365** | **TOTALS** | **$400,000.00** | **4325400** | **$412,000.00** | **4259600** | **$141,183.59** | **160435.9** |
| **8760** | **Hours/yr** | **TOTAL COST** | $953,183.59 | | | | |

**$0.09584/kWH**

**$0.88/Therm**

# Mechanical & Electrical ANALYSIS

## Cost Comparison

*Original Design Yearly Amounts Owed*

| Energy Type | Demand | Units | Cost | TOTAL $ |
|---|---|---|---|---|
| Electrical Utility | 8,585,000.0 | kWh | $0.09 | $812,003.64 |
| Natural Gas | 160,435.9 | Therm | $0.88 | $141,183.59 |
| TOTAL | | | | $953,187.23 |

*After Re-Design Yearly Amounts Owed*

| Energy Type | Demand | Units | Cost | TOTAL $ |
|---|---|---|---|---|
| Electrical Utility | 0 | kWh | $0.09 | $0.00 |
| Natural Gas | 397,704 | Therm | $12.00 | $349,979.52 |
| TOTAL | | | | $349,979.52 |

*After Re-Design Yearly Amounts Paid From Utility*

| Energy Type | Output | Units | Cost | TOTAL $ |
|---|---|---|---|---|
| Electrical Production | 16,644,000 | kWh | $0.06 | $957,030.00 |
| Demand Available | 22,800 | kW | $5.90 | $134,520.00 |
| TOTAL | | | | $1,091,550.00 |

# analysis RESULTS

## COST analysis

### Total Savings

*After Re-Design Yearly Totals*

| Energy Type | TOTAL $ |
|---|---|
| [-] Natural Gas Bill | $349,979.52 |
| [+] Amt Saved from Redesign | $953,187.23 |
| [+] Income From Utility | $1,091,550.00 |
| TOTAL [+] | $1,694,757.71 |

$1.7 Million/yr

### Payback

| Project Cost | Annual Operating Cost | Net Savings | Simple Payback |
|---|---|---|---|
| $5,058,593.00 | $349,979.52 | $1,694,757.71 | 3.0 yr. |

# Mechanical & Electrical ANALYSIS

## TSRI CAMPUS IMPACT
## 351,803 SF

The 3 Building Campus Total Cost - $168 Million – $477.54/SF

Up Front Investment comes to an addition of - $14.38/SF

From the Information Contained on the Actual Utility Bills The Co-Generation Design Produces Enough Power to Completely Eliminate Electrical Supply from the Grid with Additional Power To Sell Back to the Grid

- Reduce Carbon Footprint by 63% Saving 12,029 Tons $CO_2$/yr
  - Original: 19,080.107 Tons $CO_2$/yr from Electrical & NG Demand
  - After Re-design 7,051.292 Tons $CO_2$/yr for NG to run Turbine

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## analysis THREE

### Alternate Forming Method

BACKGROIUND

Original Forming was conventional hand built timber and plywood constructed in the field

PROPOSAL

Utilize Flying Forms for the structural erection

GOALS

Reduce Construction Schedule
Reduce Waste in the forming process
Reduce Cost

## Formwork ANALYSIS

# Formwork ANALYSIS

## Flying Forms For THE SCRIPPS RESEARCH INSTITUTE


# analysis THREE

## DESIGN methodology



- Review the Original Forming System & Compare
  - Analyze the Cost of the Original System
  - Analyze the Schedule of the Original System
- Alternate Method
  - Model Structure in Revit Structure
  - Create Takeoff
- Estimate
  - Durations & Cost for Both Methods of Installation
  - $MC^2$ and Industry Professional Information

# Formwork ANALYSIS

## FORMING METHOD COMPARISON

| System | Components | Typical Column Forms | Typical Floor Forms | Method | Cycle | Cost | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|---|
| Conventional | Field built wood and steel gang forms | Either sheet plywood or MDO with pre-fabricated column clamping system | Hand built, jack shore supported plywood / MDO | Crane and hand set. | 15 days per production floor area | +20% over a mean average | Best used where the structural design indicates multiple differing conditions; the number of floor penetrations is excessive and varies by size. Offset integral structure | Cost of material and labor; forms tend to be easily damaged; waste; no recycling potential. Slow cycle. Numerous re-shores interfere with the ability of other trades to access work areas. |
| Flying – Conventional slabs | Pre-engineered element forms with field applied facing | Walls or columns, pre-engineered forming systems suitable for multiple re-use | Truss supported flat forms that can be dropped , in place and pulled through the face of the building | Crane set | < 9 days per floor depending on concrete specifications. Use of "high early" concrete prevalent with this system | -10% under a mean average | Best used for hi-rise buildings with large bay spacing and clear slab edges. Premium re-use of components. Minimal waste. Small penetrations call be core drilled at later date. | Requires modular structural layout without excess of unique features, drop beams, etc. Requires additional re-shoring in terms of material and time to leave shores in place. |
| Flying – Post Tensioned slabs | Pre-engineered element forms with field applied facing | Walls or columns, pre-engineered forming systems suitable for multiple re-use | Truss supported flat forms that can be dropped , in place and pulled through the face of the building | Crane set | < 10 days per floor depending on concrete specifications. Use of "high early" concrete prevalent with this system | -15% under a mean average | Best used for hi-rise buildings with large bay spacing and clear slab edges. Also , multi story condominiums. Premium re-use of components. Minimal waste.<br><br>Requires less shorting because floors are tensioned structures. Column forming can commence the same day after the floor sets | Requires modular structural layout without excess of unique features, drop beams, etc. Penetrations must all be laid out in advance due to potential of cutting cables with core drilling. Floors camber during tensioning; therefore systems is not suitable where F35 flatness or greater is required. |

# Formwork ANALYSIS

## Conventional Forming on The Biomedical Research Building

# analysis RESULTS

## Production IMPACT

- Conventional Forming System
  - Forming Shoring of Decking Done Simultaneously
    - -Left in Place Until Concrete Reached 28 Day Design Strength
  - New Formwork For Each Level, no Re-use
- Flying Formwork System
  - Form & Shore Deck with Truss System for Initial Pour
    - -Utilizing High Early Strength Concrete Pull Forms after 4 Days
  - Jump Flying Truss Forms to Next Level
    - Re-Shore the Deck of the Lower Level as Truss is Pulled
  - Re-use the Forming System Floor to Floor

# Formwork ANALYSIS

## Flying Forms For The Biomedical Research Building

# Formwork ANALYSIS

## COST COMPARISON

*Cost Comparison of the Two Forming Methods*

| Conventional Forming Items | Cost |
|---|---|
| Administrative Requirements | $135,360 |
| Temporary Facilities | $365,195 |
| Execution Requirements | $54,128 |
| **Structural CIP Forms** | **$1,740,156** |
| Concrete Accessories | $210,184 |
| Reinforcing Steel | $538,822 |
| Structural Concrete | $687,569 |
| Finishing | $171,374 |
| Curing | $33,852 |
| *TOTAL* | $3,936,640 |

| Flying Formwork Items | Cost |
|---|---|
| Administrative Requirements | $101,520 |
| Temporary Facilities | $325,140 |
| Execution Requirements | $53,379 |
| **Structural CIP Forms** | **$1,375,163** |
| Concrete Accessories | $210,184 |
| Reinforcing Steel | $538,822 |
| Structural Concrete | $687,569 |
| Finishing | $171,374 |
| Curing | $33,852 |
| *TOTAL* | $3,497,003 |

# analysis RESULTS

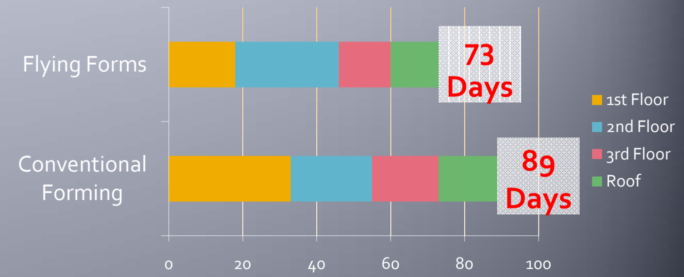
## SAVINGS Impact

- COST *saves $3.31/SF*
  - **$440,000 In Savings is Realized Through Utilizing Flying Forms**
    - -reduced waste
    - -re use of forms
- SCHEDULE
  - **16 Days are Saved in the Construction Schedule**
    - -high early strength concrete
    - -re use of forms



# Formwork ANALYSIS

## SCHEDULE COMPARISON



# Pre-Fab & Formwork ANALYSES


# Technical ANALYSES

## Conclusions & RECOMMENDATIONS

✓Prefabrication of Island Mechanical Assembly

**Allows the Laboratory finishes to be completed 58 days earlier**

**Estimated Savings roughly $37,000**

✓Flying Forms

**Reduces Waste**

**Allows the Structural phase to be completed 16 days earlier**

**Estimated Savings of nearly $0.5 Million Dollars**

✓Co-Generation Facility

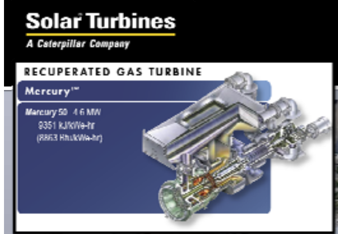
**Creates Savings of nearly 1.7 Million each year**

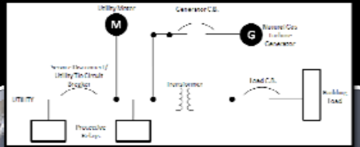
**High Initial Investment paid for in 3 years**

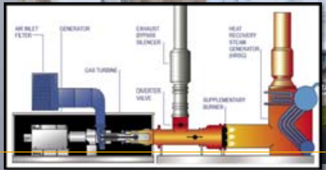
**Carbon Footprint of TSRI Reduced by 63%**



# Co-Generation ANALYSIS





## INDUSTRY research

PREFABRICATION & BIM

- ~~PROJECT OVERVIEW~~
- ~~TECHNICAL ANALYSES~~
  - ~~*ANALYSIS ONE* – PREFABRICATION OF LAB ISLAND ROUGH-IN~~
  - ~~*ANALYSIS TWO* – CO-GENERATION – *Mechanical & Electrical Breadth*~~
  - ~~*ANALYSIS THREE* – ALTERNATE FORMING METHOD~~
- INDUSTRY RESEARCH OF PREFABRICATION & BIM
- ACKNOWLEDGEMENTS
- QUESTIONS & COMMENTS

## INDUSTRY research

| PROBLEM STATEMENT | TECHNOLOGY DEMANDS |
| --- | --- |
| Implementation has no Standard – Project Specific | Up-Front Commitment<br>Clearly Defined Scope of Work |
| Prefabrication & BIM Needs:<br>Management Execution<br>Planning<br>Standard Requirements | Early Decision Making &<br>Extensive Planning<br>Earlier Design Completion with Greater Detail |

## INDUSTRY research

PREFABRICATION & BIM

Up-Front Commitment

*Accepting Responsibility and Making a Commitment to Implementing these Technologies Successfully can be Easily Prepared for and Handled by Management.*

# INDUSTRY research

PREFABRICATION

BENEFITS OF PREFABRICATION

Reduced Construction Costs
Schedule Reduction
Increased Quality
Reduced Waste
Increased Safety
Site Congestion

# INDUSTRY research


# INDUSTRY research

PREFABRICATION

*The controlled environment leads to reduced construction cost, shorter construction & installation time, reduced waste, an increase in quality and a higher degree of safety.*

## INDUSTRY research

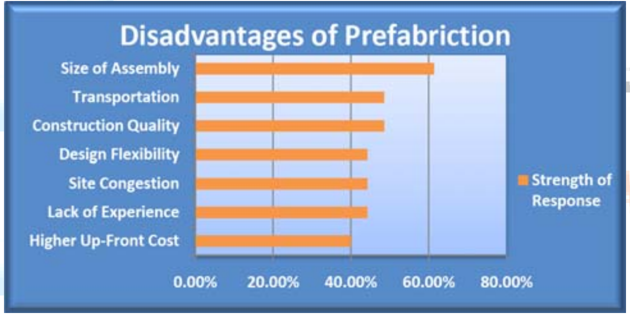
### PREFABRICATION

DISADVANTAGES OF PREFABRICATION

Size of Assembly & Transportation

Design Flexibility

## INDUSTRY research




## INDUSTRY research

### PREFABRICATION

*The size & weight of prefab assemblies is an essential concern when considering what can effectively be transported to the site without complicating the installation process.*

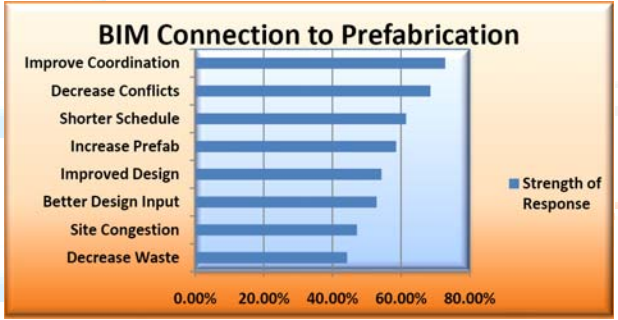
# INDUSTRY research

## BIM & Prefabrication

BIM CONECTION TO PREFABRICATION

Increase Opportunity for Prefabrication
Improve Coordination
Decrease Field Conflicts
Shorten Schedule
Material Staging
Better Design Input

# INDUSTRY research




# INDUSTRY research

## BIM & Prefabrication

*The increase in coordination and earlier design finalization leads to decreased conflicts in the field.*

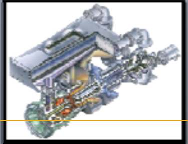
*BIM helps but issues in the field offset its full potential. The Learning Curve with this technology calls for more ROI studies.*

# INDUSTRY research

## BIM & Prefabrication at The SCRIPS Research Institute

### Benefits of Implementing Pre-Engineered Systems & Technology

- Prefabrication of the Mechanical Islands
- Utilizing Prefabricated Flying Forms
- Containerized Delivery of Turbine



# INDUSTRY research

## CONCLUSIONS & RECOMMENDATIONS

✓ Change is Coming, Prepare and Assist:

BIM Leader Within Each Company

Educational Plan to Mitigate Learning Curve

Integrated Design Build Approach

Highlight Positive Impact of Technology

Document Results of Implementation

LEAD, PROMOTE & CHALLENGE

# INDUSTRY research

## BIM & Prefabrication at The SCRIPS Research Institute

### Benefits of Implementing Pre-Engineered Systems & Technology

- BIM Streamlining of all assembly installations, forming processes and materials staging of deliveries

# ?? QUESTIONS ??


## ACKNOWLEDGEMENTS

SAUER, INC.

ISEC, INC.

FLUOR

AE FACULTY

BRIAN AULT

MY FIANCÉ, FRIENDS & FAMILY


# ?? QUESTIONS ??

# Co-Generation calculations

## Quantify Building Loads

Thermal Loads

- [2] 5400 MBH Hot Water (8,640)
- [2] 8000 MBH Steam (12,500)
- [2] 1050 Ton Electric Centrifugal Chillers

Building loads Total

- 7,300 MBH $H_2O$
- 1,300 Ton Cooling
- 12,500 Steam
- 6.5MW electrical (6.356MW)

(eliminate 1400kVA Electric Centrifugal Chiller)
Makes electrical Load = 5.67MW electrical

$$\frac{21,440,000\ \dot{Q}}{19,359,600} = 1.107$$

## Additional Cooling for the Air Intake of the Turbine

**Outdoor Air Design Conditions**

- 95°F @60%RH
  $T_{dp} \cong 78°F$
  $w = 0.022$

**Desired Supply Air Conditions**

- $\dot{V}$=30,000 cfm ⇒ @ 60°db 80%RH
  $\dot{m}=2.300\frac{BTU}{min}$ $h=24\frac{BTU}{lbm}$ $w=0.009\frac{lbm\ H_2O}{lbm\ air}$
  $\rho=13.1\frac{ft^3}{lbm}$

$\dot{Q}_{Sens}=(1.1)(30,000)(95-60)=1,155,000\frac{BTU}{hr}$ (ΔT)
=97 Tons

$\dot{Q}_{Latent}=(4,850)(30,000)(0.022-0.009)=1,891,500\frac{BTU}{hr}$ (Δw)
=158 Tons

$COP_{abs} \cong 0.75$
≅260 Tons Additional @ absorber

$0.75=\frac{260\ Tons}{(energy\ in)}$ =347 "Tons" energy in
$=4,164,000\frac{BTU}{hr}$
$=4,350\frac{lbm\ steam}{hr}$ @ 5psig

# Co-Generation calculations

## Steam Requirements & Steam Turbine Power Calculation

$3,412\frac{BTU}{hr}=1kW$

$2000_{tons}$ @ COP = 0.75 = 2670 "Tons" of steam
$=32,040,000\frac{BTU}{hr}$
@5psig steam, $h_{fg}=960\frac{BTU}{lbm}$
$=33,400\frac{lb}{hr}$ 5psig steam

@150psig, $h_g=1195.1\frac{BTU}{lbm}$
@100psig, $h_g=1190\frac{BTU}{lbm}$
@5psig, $h_g=1156.1\frac{BTU}{lbm}$

$\dot{Q}_{out\ 1}=\left(1,300\frac{lbm}{hr}\right)\left(1,195.1-1190\frac{BTU}{lbm}\right)=66,300\frac{BTU}{hr}$ out

$\dot{Q}_{out\ 2}=\left(33,400\frac{lbm}{hr}\right)\left(1,195.1-1156.1\frac{BTU}{lbm}\right)=1,692,600\frac{BTU}{hr}$ out
$=1,758,900\frac{BTU}{hr}$
$=2,000,000\frac{BTU}{hr}$
~590kW "extra" @ Steam Turbine

## NG Req. for Turbine & Duct Burner

Fuel In = $40.5\frac{MMBTU}{hr}$ @ GT
$+94.8\frac{MMBTU}{hr}$ @ Duct Burner
$=135,300\frac{BTU}{hr}$ $\dot{m}$ Total
$=135,300\ ft^3\frac{NG}{hr}$
=2,255 cfm NG @ 300psig

# Co-Generation calculations

## Total Steam Requirements

NEW SYSTEM COMPONENTS DESIGN

- Chiller Plant – 1300 Tons for the Buildings + 300 Tons @ Turbine air intake cooling
  - [2] 1000 Ton absorber chillers
  - [1] 1000 Ton electric centrifugal chiller
- Steam Plant: $13,000\frac{lb}{hr}$ 100psig steam for the Buildings
  $+\ 33,400\frac{lb}{hr}$ 5psig steam for absorbers

  $=46,400\frac{lbm}{hr}$ steam

Hot Water = $9,600,000\frac{BTU}{hr}=10,000\frac{lbm}{hr}$ 5psig steam

Total Steam = $56,500\frac{lbm}{hr}$

The conclusion this leads to is the requirement for the BIG Duct Burner with the Mercury 50 to 2800°F

# Co-Generation calculations

*Original Design Yearly Amounts Owed*

| Energy Type | Demand | Units | Cost | TOTAL $ |
|---|---|---|---|---|
| Electrical Utility | 8,585,000.0 | kWh | $0.09 | $812,003.64 |
| Natural Gas | 160,435.9 | Therm | $0.88 | $141,183.59 |
| TOTAL | | | | $953,187.23 |

*After Re-Design Yearly Amounts Owed*

| Energy Type | Demand | Units | Cost | TOTAL $ |
|---|---|---|---|---|
| Electrical Utility | 0 | kWh | $0.09 | $0.00 |
| Natural Gas | 397,704 | Therm | $12.00 | $349,979.52 |
| TOTAL | | | | $349,979.52 |

*After Re-Design Yearly Amounts Paid From Utility*

| Energy Type | Output | Units | Cost | TOTAL $ |
|---|---|---|---|---|
| Electrical Production | 16,644,000 | kWh | $0.06 | $957,030.00 |
| Demand Available | 22,800 | kW | $5.90 | $134,520.00 |
| TOTAL | | | | $1,091,550.00 |

*After Re-Design Yearly Totals*

| Energy Type | TOTAL $ |
|---|---|
| [-] Natural Gas Bill | $349,979.52 |
| [+] Amt Saved from Redesign | $953,187.23 |
| [+] Income From Utility | $1,091,550.00 |
| TOTAL [+] | $1,694,757.71 |

| Project Cost | Annual Operating Cost | Net Savings | Simple Payback |
|---|---|---|---|
| $5,058,593.00 | $349,979.52 | $1,694,757.71 | 3.0 yr. |

# Co-Generation calculations

**Calculating the cost comparison of the two systems with respect to Billing Amounts**
$0.88/Therm = 1,000,000 Btu

**Gas Turbine NG Requirements** – *Running the turbine at 63% capacity at all times producing* ***3 MW= 26.4*** $\frac{Therms}{hr}$

$$\left(8760\frac{hr}{yr}\right)\left(26.4\ \frac{Therms}{hr}\right) = 231{,}264\ \frac{Therms}{yr}$$

**Duct Burner NG Requirements** – *Running the burner at 40% capacity for half the year to meet additional steam requirements for the Absorption Chiller requirements =* ***38*** $\frac{Therms}{hr}$

$$\left(4380\frac{hr}{yr}\right)\left(38\ \frac{Therms}{hr}\right) = 166{,}440\ \frac{Therms}{yr}$$

Adding these two numbers you come up with a total of 397,704 $\frac{Therms}{yr}$
This would cost **$349,979.52 /yr**

**According to the Billing Information** – *The demand is approximately 1.1 MW at all times. Running our Turbine to produce 3 MW at all times means that we will be supplying 1.9 MW to the grid.*

$$\frac{(1900kW)(8760hr)\left(\frac{\$0.0575}{\text{kWH}}\right)}{\text{yr}} = \$957{,}030/\text{yr}$$

*There will also be an income amount based on the available demand to the grid*

$$(1900kW)\left(\$5.90/\frac{\text{kW}}{\text{Month}}\right)(12\ \text{Months}) = \$134{,}520/\text{yr}$$

# Co-Generation calculations

*Utility and Gas Billing for 1yr. Period*

| Days | Month-yr of Service | Bldg $ | Bldg KWH | Chiller $ | Chiller KWH | TECO GAS Supplier | Therms N Gas |
|---|---|---|---|---|---|---|---|
| 30 | Apr-07 | $30,000.00 | 320000 | $24,000.00 | 227600 | $13,748.15 | 15622.9 |
| 31 | May-07 | $31,000.00 | 334000 | $34,000.00 | 343600 | $12,205.34 | 13869.7 |
| 30 | Jun-07 | $34,000.00 | 371600 | $42,000.00 | 447200 | $12,260.95 | 13932.9 |
| 31 | Jul-07 | $34,000.00 | 366400 | $44,000.00 | 465200 | $9,374.02 | 10652.3 |
| 31 | Aug-07 | $33,000.00 | 352800 | $44,000.00 | 464400 | $9,749.78 | 11079.3 |
| 30 | Sep-07 | $36,000.00 | 389600 | $46,000.00 | 490400 | $8,648.73 | 9828.1 |
| 31 | Oct-07 | $32,000.00 | 345600 | $37,000.00 | 393200 | $8,990.70 | 10216.7 |
| 30 | Nov-07 | $36,000.00 | 390000 | $30,000.00 | 304000 | $11,704.09 | 13300.1 |
| 31 | Dec-07 | $34,000.00 | 364800 | $28,000.00 | 288400 | $12,829.34 | 14578.8 |
| 275 | SubTotal | $300,000.00 | 3234800 | $329,000.00 | 3424000 | $99,511.10 | 113080.8 |
| 31 | Jan-08 | $36,000.00 | 393800 | $24,000.00 | 239600 | $14,017.26 | 15928.7 |
| 28 | Feb-08 | $32,000.00 | 348400 | $30,000.00 | 311600 | $13,158.73 | 14953.1 |
| 31 | Mar-08 | $32,000.00 | 348400 | $29,000.00 | 284400 | $14,496.50 | 16473.3 |
| 365 | TOTALS | $400,000.00 | 4325400 | $412,000.00 | 4259600 | $141,183.59 | 160435.9 |
| 8760 | Hours/yr | TOTAL COST | $953,183.59 | | | | |

Customer Charge – **$375.00/Month**

| | ON – PEAK | CHARGES | OFF – PEAK | |
|---|---|---|---|---|
| | $0.00634/kW | BASE | $0.00508/kW | |
| | $0.05928/kW | NRG | $0.05432/kW | |
| | $0.00071/kW | Environmental | $0.00071/kW | |
| | $0.00012/kW | Storm | $0.00012/kW | |
| $0.06805/kW | $0.00160/kW | Conservation | $0.00160/kW | $0.06183/kW |
| | $5.90000/kW | Demand | $5.90000/kW | |
| | $3.08000/kW | Capacity | $3.08000/kW | |

*The 1st Boxed # is the amount we will be paid by the utility for power supplied back to the grid, the 2nd boxed # is the amount we will be paid by the grid for having power available whenever they need it.*