Improving the Cornell Plant with New Package Boilers

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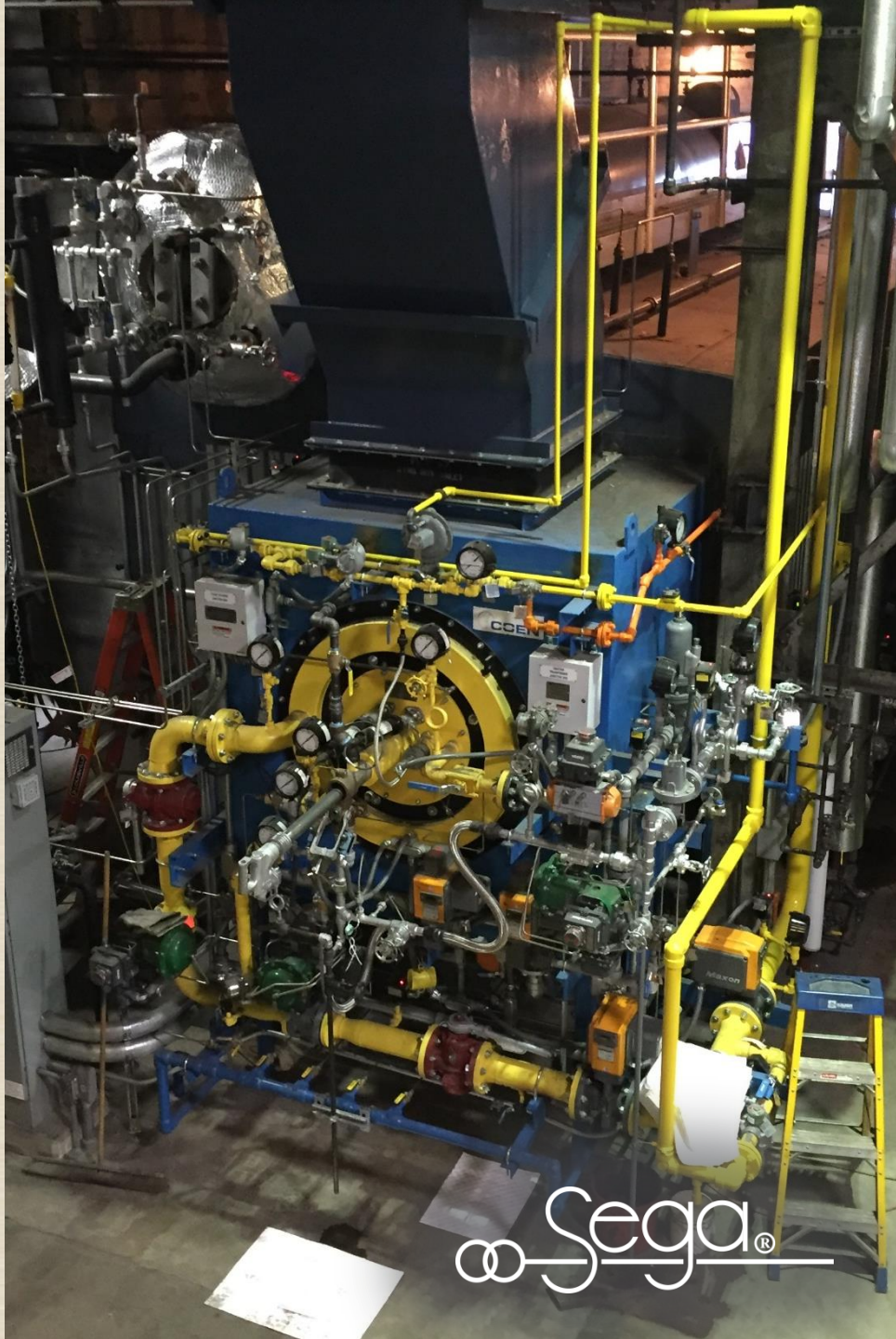


Central Energy Plant (CEP)

The CEP provides steam, electricity, & chilled water to over 160 campus buildings, equating to approximately 14 million gross square feet on central campus.

CEP Summary

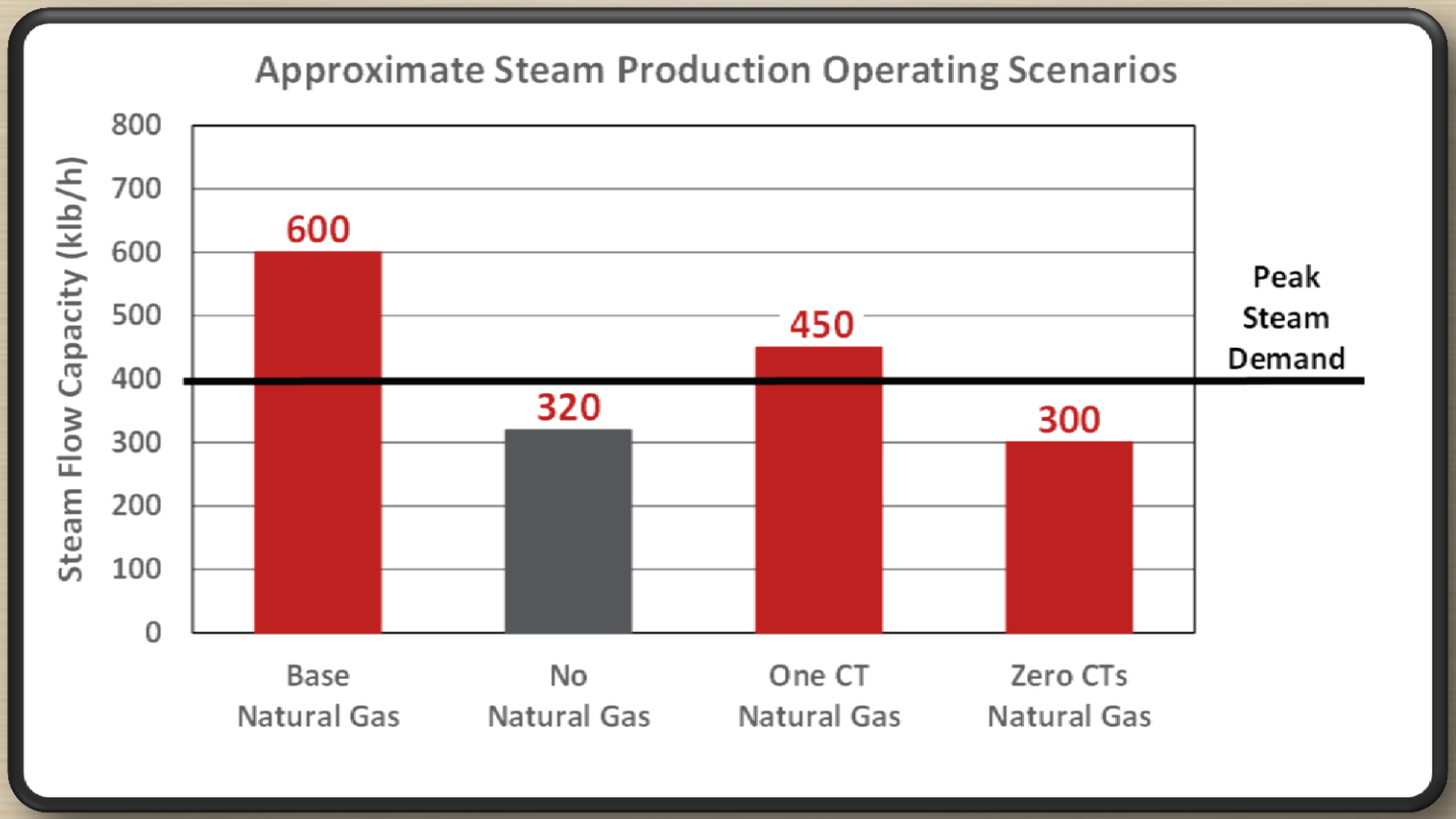
CORNELL STEAM GENERATION RESOURCES

Unit	Year Installed & Manufacturer	Fuel(s)	Capacity (klb/h)
CT/HRSG 1	2009 Solar Titan/Rentech	Natural Gas #2ULSD	60 (unfired) 150 (duct fired)
CT/HRSG 2	2009 Solar Titan/Rentech	Natural Gas #2ULSD	60 (unfired) 150 (duct fired)
Boiler 5	1965 B&W	Natural Gas	100
Boiler 6	1992 Foster Wheeler	Natural Gas #2ULSD	100
Boiler 7	1992 Foster Wheeler	Natural Gas #2ULSD	100

Why New Boilers?

- **Improve reliability (Goal—99.9% reliable steam export)**

  ➡ *Cover Peak Steam Demand of 400 klb/h for Failure Scenarios*



- **Plant modernization (existing boilers 25-50 years old)**

New Boilers Over Temporary Boilers

- **More cost effective**
  - ✓ *Anticipated Cost (2011) $250,000/year vs. Actual Cost (2013) $420,000/year*
  - ✓ *Life cycle costs of rental vs. new boilers = $4 million savings over 20 years*
- **Reduced uncertainty**
- **Improved reliability**
- **Improved plant maintenance access**
  - ✓ *Free CT maintenance aisle space where rental boilers were located*
  - ✓ *Utilize space of two inactive boilers to be demolished (starting 2012)*

Evaluation of New Boiler Alternatives

- **Reviewed New Boiler Options: Performance, Cost, Schedule, Risks**
  - *Option 1: Two 75-kpph boilers*
  - *Option 2: One 100-kpph boiler*
  - *Option 3: One 150-kpph boiler*

- **Study recommended Option 1 - Two 75-kpph D-Style boilers:**
  - *Fit space well and relative ease of move-in*
  - *Capacity to meet peak steam demand for failures*
  - *Highest degree of operational flexibility & plant reliability*
  - *Highest operational efficiency (low load / min. fire operation)*

Project Schedule

Start Design

January 2014

- 1st of three Key Internal Approvals (typ. = 1 month): Design

Project

20 Months

- 2nd Key Internal Approval: Boiler Procurement
- Boiler Shop Drawing Review/Approval: 3.5 months
- Boiler Design/Fabrication: 9 months from Sept. 2014
- Design and Bid: 4 months
- 3rd Key Internal Approval: Installation
- Annual Steam Shutdown (May 2015)
- Installation: 6 months from Steam Shutdown

Boilers

Operational - October 2015

Project Budget

Breakdown	Conceptual Design	Actual Costs *(Projected Feb. 2015)*
Construction	$1,400,000	$2,300,000
Engineering (Design, air permitting, compliance testing)	$700,000	$700,000
Equipment, Start Up, Training	$3,200,000	$3,500,000
Cornell Internal Project Costs	$400,000	$200,000
Project Contingency	$1,100,000	$100,000
TOTAL	**$6,800,000**	**$6,800,000**

Conceptual Design

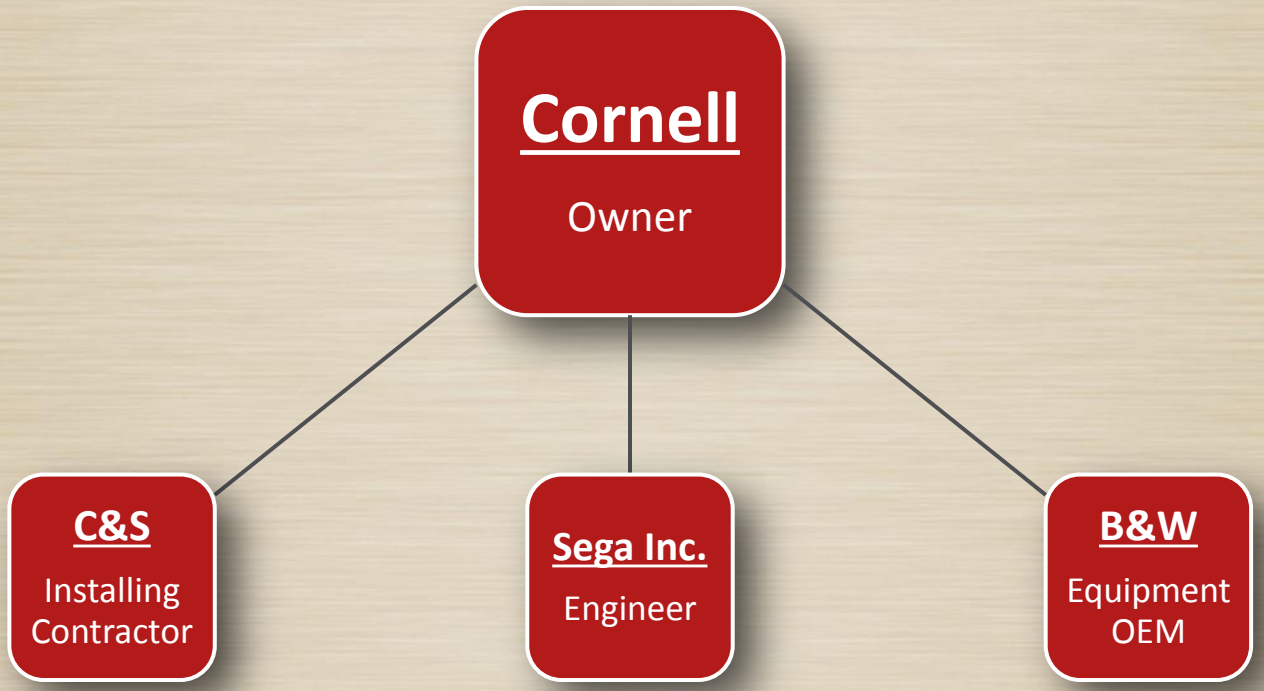
- Contractor provided input for installation
- Boiler OEM budget quotes

Project

- Construction costs higher than anticipated (customization)
- Boiler costs higher than anticipated (customization)

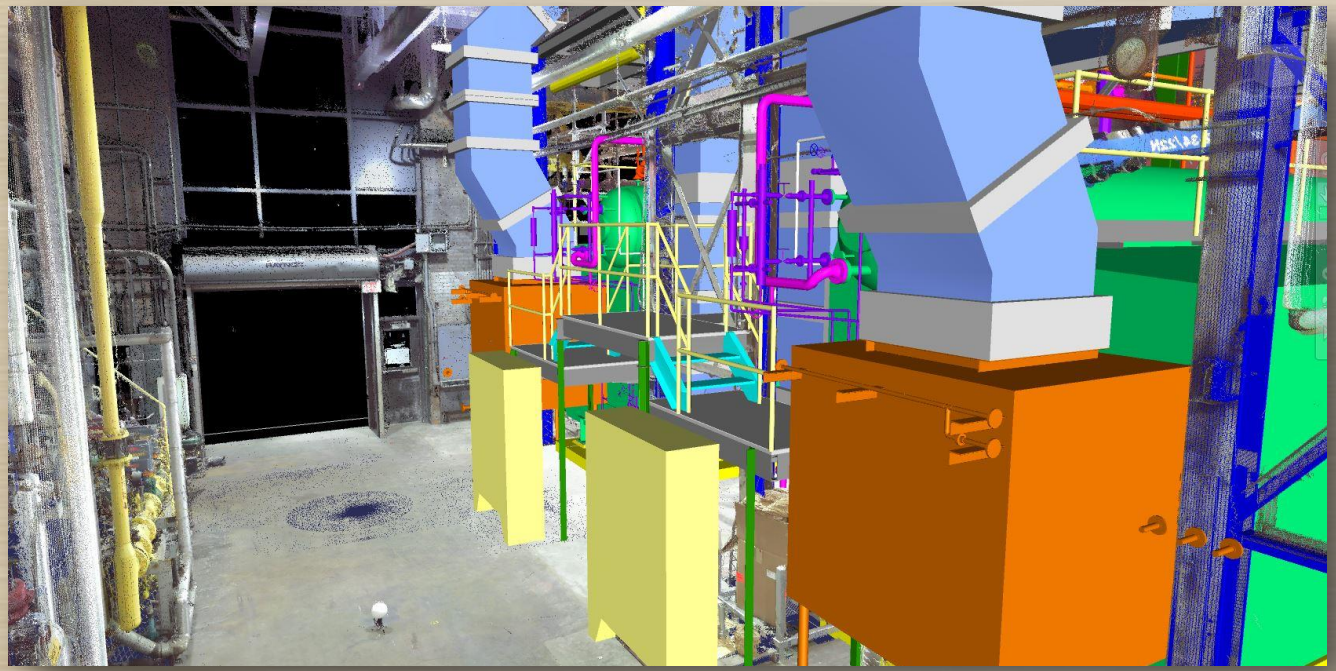
Held to Conceptual Design budget, Reduced Cornell Project Costs to Offset Overage

Project Team



- Installation contractor self performed all work (subcontracted electrical & rigging)
- Competitive RFP Process
- OEM supplied boilers (trim, inst., burners, controls, fans, VFD, breeching)
- Dedicated experienced operator for Owner (helped process)

Design Phase; Some Key Considerations

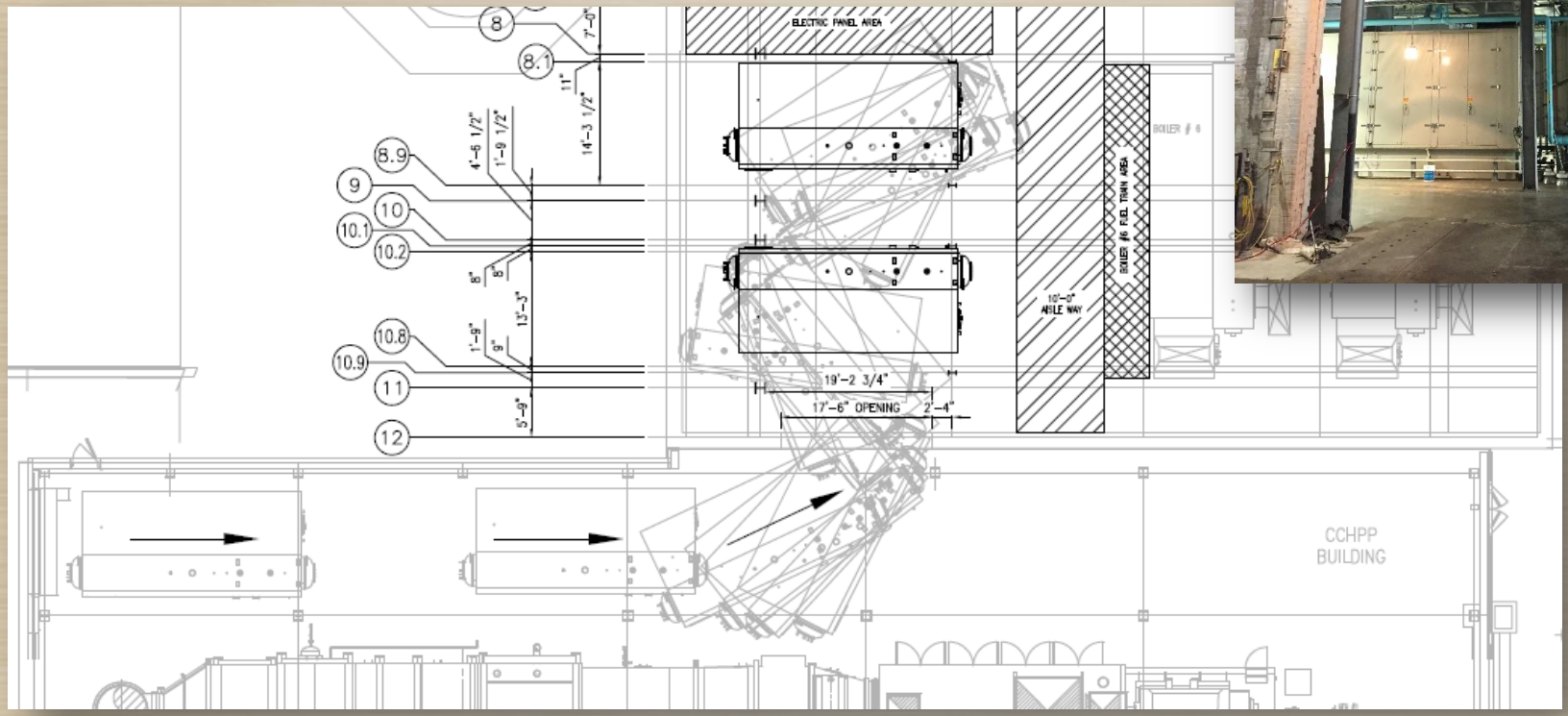


Verify existing plant dimensions and layout.

- ✓ *As-builts may not be correct*
- ✓ *Hold contractor responsible for field verification prior to fabrication*
- ✓ *Use 3-D scanner for field verification with 3-D model*
- ✓ *Verify adequacy of existing structural, electrical, mechanical systems for new equipment*

Design Phase; Some Key Considerations

- **Consider the installation route for move-in**
  - ✓ *Move-in path modeled to verify boiler size constraints*
  - ✓ *Make changes in plant to accommodate move-in*
  - ✓ *Work with local rigging contractor to verify plans*
  - ✓ *Consider shoring requirements for existing floor*



Design Phase; Some Key Considerations

- **Plan schedule phases to prevent contractor interferences (not that easy!)**

- **Identify owner preferences**
  - ✓ Access preferences
  - ✓ Operational preferences
  - ✓ Redundancies / spares
  - ✓ Manufacturer preferences
  - ✓ Design standards
  - ✓ Tagging / Identification

Plan for Construction Phase Risks

- Unclear communication of responsibilities/supply could cause budget and schedule issues.
  - ✓ *$3.5 million in Owner Supplied equipment on a $2.0 million dollar construction cost*
  - ✓ *Bid documents did not contain approved OEM drawings*
- Not receiving air permit could delay construction.
  - ✓ *Air Permit received June 2015—just in time*
- Missing outage windows for tie-ins could result in need for additional outages, costs, and schedule delays.
  - ✓ *Enabling work was done during May shutdown*

Startup and Testing

Field Checkout	• Combination of Engineer, Owner, and Boiler OEM • Two boilers with two fuels require more time
Boil Out	• Chemical Vendor and Owner
Steam Blows	• Procedure prepared by Engineer • Contractor supply of valve/piping/silencer • Boiler OEM and Owner operating equipment
Tuning	• Controls Field Service from Boiler OEM • Training opportunity for operators (3 week period) • Control of gas between core and spuds was issue
Testing	• Stack tests passed on both boilers for both fuels on 1/13/16
Training	• Onsite by Boiler OEM • Customized for Cornell • Four 8 hour training shifts (so all shifts get day training)

Current Status

- Stack testing complete: We passed!
- Final checkout / punchlist items
- Performance testing complete
- Supplying steam to Campus

Questions