CHP Development

Hindsight is 20/20
Introduction

Speakers

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Objective

• Discuss lessons learned from each phase of the UAF CHPP Replacement Project

• Utilize the framework provided by the CHP Project Development Guide
  – US EPA Combined Heat and Power Partnership
The University of Alaska Fairbanks

- Founded in 1917
- Located in Fairbanks Alaska
- Approximately 10,000 students at the Fairbanks campus
- 3,400,000 square feet of academic, research, administrative and housing space
- $124 Million in Research grants per year
- Extreme temperature variation: -66°F to 99°F
- Approximately 14,000 degree heating days
CHPP Replacement Project Status

- Construction complete
- Startup and commissioning in progress
- Turbine-Generator sync to grid: Sept 4
- First fire on natural gas: Sept 25
- First fire on coal: Dec 19
- Anticipated Completion: Mid April
CHP Project Development Guide

- Formerly the CHP Project Development Handbook
- How-to guide for
  - New installations
  - Retrofit/Replacement of existing CHP facilities
- Project development framework
  - Five stages of development
- Tools and resources
  - Forms / Questionnaires
  - Estimators / Spreadsheets
  - Sample Reports
  - Checklists
- All information (and more) available on EPA website
  https://www.epa.gov/chp
The Five Stages of Project Development

• Stage 1 - Qualification
  – Is CHP a good fit?

• Stage 2 – Level 1 Feasibility Analysis
  – High level screening
  – Fatal flaws
  – Project hurdles
  – Cost

• Stage 3 – Level 2 Feasibility Analysis
  – Finalization of design basis
  – Finalize project economics

• Stage 4 – Procurement
  – Detailed Design
  – Equipment Procurement
  – Construction
  – Startup and Commissioning

• Stage 5 – Operation and Maintenance
Stage 1 – Qualification

One Question: Is CHP right for you?

Lessons Learned:

• Plan on completing this step even if you have an existing CHP
  – UAF has had some form of CHP since the 1930’s
  – Needed to build the case for CHP from scratch
  – Hired GLHN to conduct a screening study

• Focus on project drivers
  – 50+ year old plant
  – Insufficient capacity for future demand
  – Power is important, but heat is essential
  – Significant use of renewables is unrealistic
  – Natural gas is unavailable
  – Unnatural gas (vaporized LNG) and oil are expensive
  – Coal supply is local and affordable

• Consider a broad array of options
  – Defense against the “Why don’t we just ____” argument
  – The more visible the project, the deeper you have to dig
  – Results also useful during public outreach phase
Stage 1 – Qualification

Lessons Learned:

- Consider secondary factors
  - Impacts of a failure (resiliency)
  - Local grid reliability
  - Likelihood of natural disasters
  - Does the plant support a “Place of Refuge?”
  - Would you consider your facility “essential?”
  - Does your facility stand out to the public

- ???
Stage 2 – Level 1 Feasibility Analysis

Primary Activities:
• Conceptual Design / Project Scoping
• Environmental studies / early permitting
• Budgetary cost estimate

Lessons Learned:
• Power, Heat, or Both?
  – Heat is essential in cold climates
  – Power is more valued in hot climates
  – Many facilities are somewhere in the middle
  – Local factors can have a large influence
• Energy needs determine technology
  – Thermal plants generate heat, power comes second
  – Gas turbines and engines generate power, heat comes second
  – Hybrid options are possible
• Do not constrain scope or costs
  – If it might be necessary, include it
  – Square footage is your friend
  – Easier to reduce scope or costs later
• Perform environmental engineering in parallel
  – Include emission points that may or may not be needed
  – A local environmental consultant can be invaluable
Stage 3 – Level 2 Feasibility Analysis

Primary Activities:
• Project design basis
• Contracting and procurement philosophy
• Project schedule
• Design optimization
• Refined cost estimate
• Project funding
• Early procurement
Stage 3 – Level 2 Feasibility Analysis

Lessons Learned:

- **Lather, rinse, repeat…**
  - The activities in this stage are iterative
  - UAF repeated Stage 3 at least 3 times

- **CMAR can be an effective contracting approach**
  - Best when there are many "unknown unknowns"
  - Requires an active owner
  - Likely not lowest first cost approach
  - Approach is much more tolerant of change
  - Reduces uncertainty relating construction methods before price is finalized

- **Keep stakeholders in the loop**
  - Both internal and external stakeholders
  - Consider PR help for high visibility projects

- **Focus on design optimization**
  - Consider both peak and off-peak loads in plant design
  - Be prepared to cut non-essential scope
Stage 3 – Level 2 Feasibility Analysis

Lessons Learned Continued:

• Consider early procurement of major equipment
  – Gets ball rolling on long lead equipment
  – Pay close attention to scope and liability boundaries
  – Can complicate project risk

• Finalize equipment and material sourcing early
  – Identify acceptable locations to source from
  – Will alternate sources be allowed as an option
  – Ensure sourcing approach is accurately reflected in bid documents

• Expect the unexpected in your schedule
  – Try to maintain float throughout the schedule
  – Startup and commissioning is likely to result in surprise delays
  – “Operational Excursions” can have a significant impact
Stage 4 – “Procurement” (a.k.a Execution)

EPA Guide lumps a lot of the project into one stage

Primary Activities:

- 4A – Detailed Engineering
- 4B – Procurement
- 4C – Construction
- 4D – Startup and Commissioning
Stage 4A – Detailed Engineering

Structural Lessons Learned:

• Choose the boiler structural steel scope carefully
  – Focus on the interface points
  – Insist on early, frequent, and direct communication with boiler vendors structural engineer

• Avoid basements
  – Design of ground floor can get very complicated
  – Particularly true in high seismic areas

• Minimize cross bracing where possible
  – Cross bracing in high seismic areas can get quite large
  – Consider use of Buckling Restrained Brace (BRB) system or similar

• Don’t use the phrase “Essential Facility” lightly
  – Structural loads get multiplied by 1.5x
  – Impacts are compounded in a high seismic area
Stage 4A – Detailed Engineering

**Mechanical Lessons Learned:**

- **Ensure sufficient equipment redundancy**
  - Consider additional redundancy for “must-run” equipment
  - Consider likely failure scenarios in redundancy decisions
  - Consider the requirements of applicable codes and the equipment manufacturers

- **Evaluate feed pump energy sources carefully**
  - Code requires a backup source of power for feed pumps on certain boilers
  - Typical backup power source is steam
  - For smaller boilers, also consider the use of an emergency generator
  - If separate steam pump is selected, size it for at least 50% capacity

- **Avoid mixing HVAC and process systems**
  - Engineering approaches are completely different
  - Installation is completely different
Stage 4A – Detailed Engineering

I&C Lessons Learned:

• Coordinate loop power requirements carefully
  – Power instruments from control cabinets
  – Design control cabinets with sufficient space (36” minimum)
  – Ensure that all equipment vendors are using the same loop voltages

• Avoid switches
  – Switches do not provide a continuous signal
  – No way to know if a switch is working or not
  – Flow/Pressure/Temperature/Level meters are a better choice for critical or high energy systems

• Procure the control system early
  – Engineer can customize design to best work with chosen system
  – Opportunity for system vendor to provide input into design

• Coordinate with electrical contractor early
  – Discuss and agree upon content of engineering deliverables
  – Consider on-site engineering support
Stage 4A – Detailed Engineering

**Electrical Lessons Learned:**

- **Use caution when selecting VFDs**
  - Be sure to understand the characteristics of the power source and the requirements of the driven load
  - Pay close attention to the drive specifications. Standard components and options can vary widely between brands

- **Pay attention to system harmonics**
  - Existing system harmonics can negatively impact plant reliability and performance
  - New generators can introduce new harmonics or make existing harmonics worse
  - Utilize transformers to mitigate system harmonics issues where possible

- **Be Prepared to perform a grid interconnection study**
Stage 4B – Procurement

• **Invest in project management / coordination software**
  – UAF utilized Aconex for all project email, RFI’s, and document management
  – Document submittals and reviews were also conducted inside the Aconex product

• **Major vendors should design using a 3D model**
  – Frequent sharing of 3D models is critical
  – Multiple design and coordination issues could have been avoided

• **Coordinate egress paths with vendors**
  – Standard specification language is not sufficient

• **Budget for engineering coordination with vendors**
  – Ensure there is one engineer for each major vendor that is tasked with engineering coordination or dedicate one engineer to coordinate with all major vendors.
  – Engineers assigned to specific systems should take responsibility for coordinating with miscellaneous equipment vendors inside their systems
Stage 4C – Construction

- Scope boundaries
- Sub-vendors
- Work plan coordination
- Communications protocols
- Delays of materials
- Commissioning agent was through the general contractor
- Wrong steel
- Impossible to clean coal unloading area
Stage 4C – Construction

- $245 Million project on budget and nearing completion
- Low fidelity Simulator
- CMAR construction method work very well
Questions?