DTE Energy®

IDEA Annual Conference 2016

Lessons Learned – Managing a Critical Steam Load with a new CHP Plant

June 2016

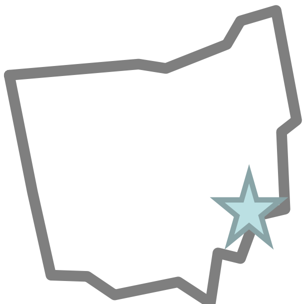
Providing fully integrated, comprehensive energy solutions

Abstract

- The DTE Marietta Cogeneration facility began commercial operations in 2015 and supplies steam to nearby industrial clients
- Due to the nature of the client's product, steam is critical and any disruption in the steam system is intolerable
- This presentation will review the lessons learned from the evolution of this steam system, from engineering to operations

Project History

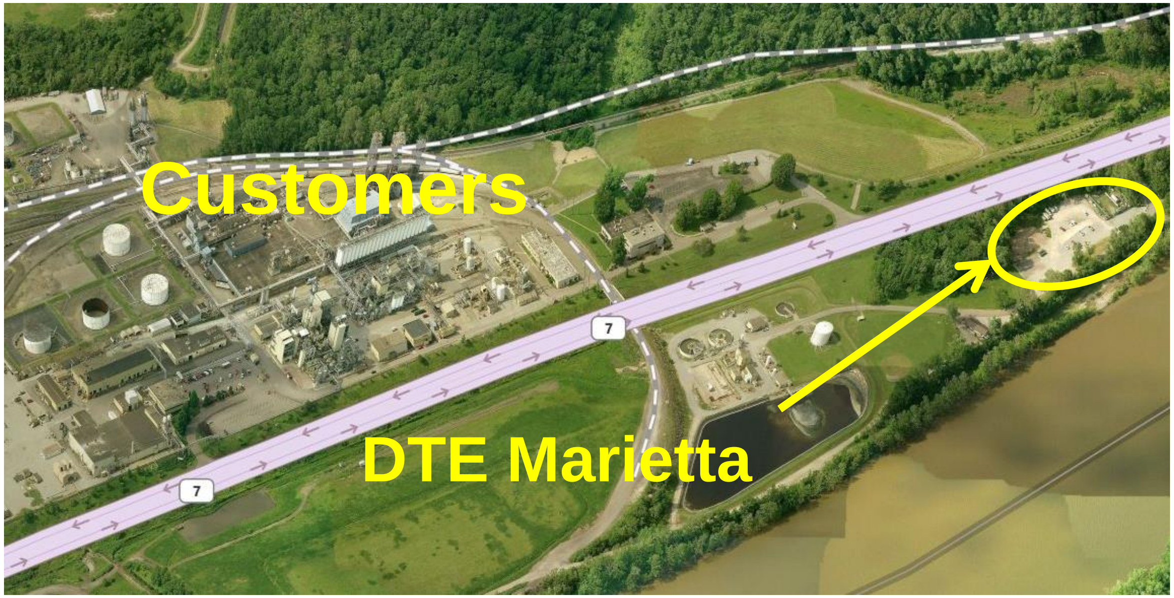
- Coal-fired utility plant shut down that supplied process steam to neighboring campus
- Campus members responded by: converting from steam to direct-fired natural gas, installing small permanent package boilers, and installing temporary boilers to allow determination of a long-term solution
- Power supply from local utility
- RFP for third party steam or CHP issued to supply campus members relying on temporary boilers
  - Nominal demand 60-120 kpph, 305 psig saturated steam with some seasonal variation
  - Peak steam demand of 150 kpph
  - Nominal power demand 7.1 MW
  - Peak power demand typically under 8 MW



Marietta, OH

Project Site

- Siting caused significant delays during detailed engineering and construction.
  - Final site was approximately 1 mile away from customers requiring lengthy interconnections to the new CHP facility:
    - 13.8 kV cable
    - 12” steam line
    - 6” condensate line
  - Final site location also required an increase of site elevation of ~10 ft due to flood plain issues with the Ohio River



New CHP Facility Highlights

- After multiple configurations were evaluated, it was decided to move forward with a 8 MW CHP Facility
  - Project cost: ~$35M
  - Construction started: December 2013
  - Commercial operation: February 2015
  - 100+ construction jobs created over 18 months
  - 10 new full-time jobs created
  - Customer reasons for CHP – control of energy reliability, reduction of energy costs
  - Customer reasons for third party – focus on core business, eliminate capital spend on utilities
  - ~$10 million of customer utility cost savings over project life

Design

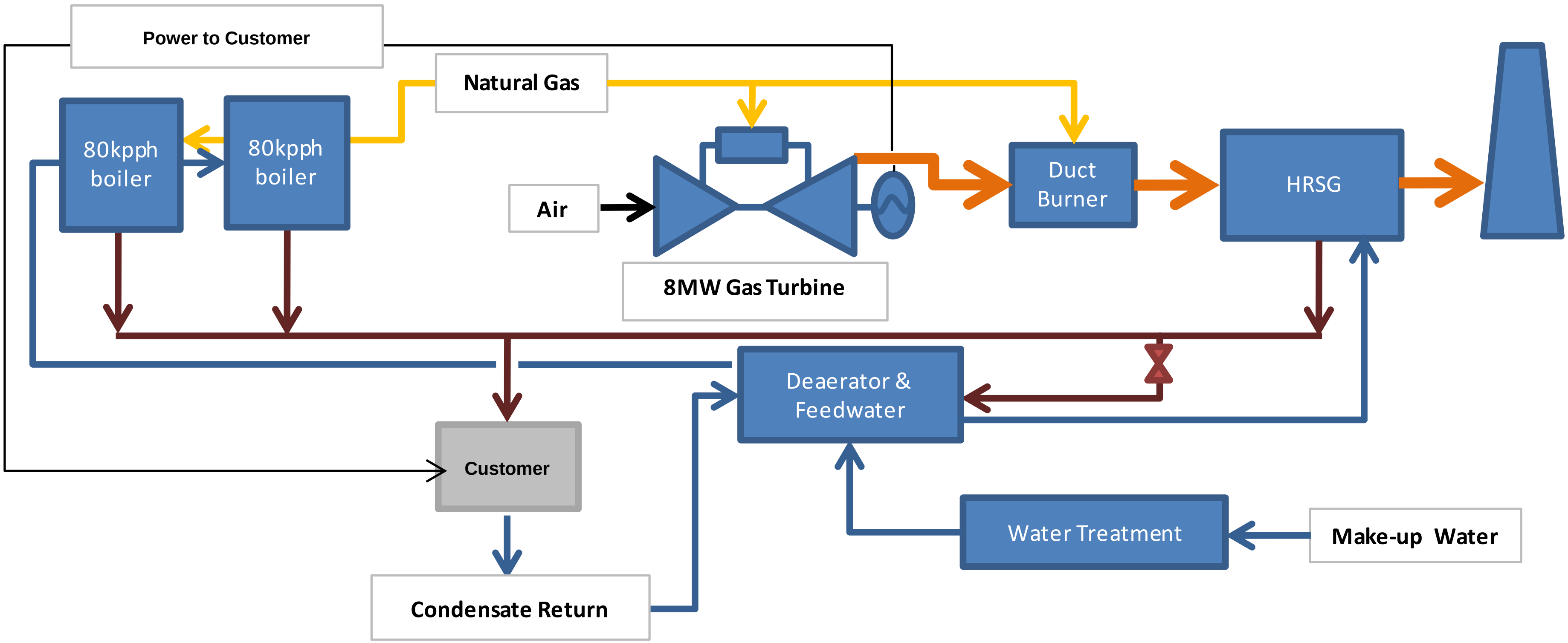
Build

Own

Operate

Maintain

New CHP Facility Configuration

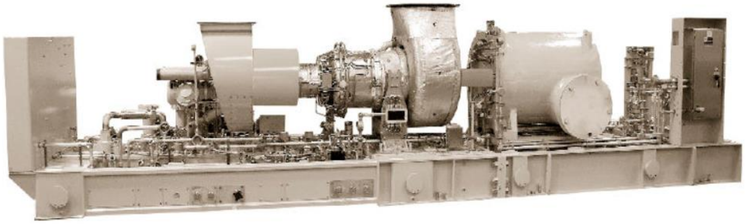


- Solar Taurus 70 GT
- 150 kpph HRSG
- 2 x 80 kpph package boilers
- Water treatment
- Black start generation
- ~1 mile of interconnects

DTE Energy

Major Equipment

- Taurus 70 gas turbine – outside:
  - Fuel: Natural gas @ ~300 psig
  - Nominal Output: ~7.1 MW at 13.8 kV



- Heat Recovery Steam Generator (HRSG) – outside:
  - Three (3) modes of operation
    - TEG – ~30 kpph
    - TEG w/ duct burners – capable of fully firing up to 150 kpph
    - Fresh Air Firing – 100 kpph
  - SCR section utilizing aqueous ammonia included for NOx reduction
  - Space for CO catalyst in the future
  - Fresh air system designed to automatically transfer upon GT trip without the need to purge the HRSG and re-fire the duct burners

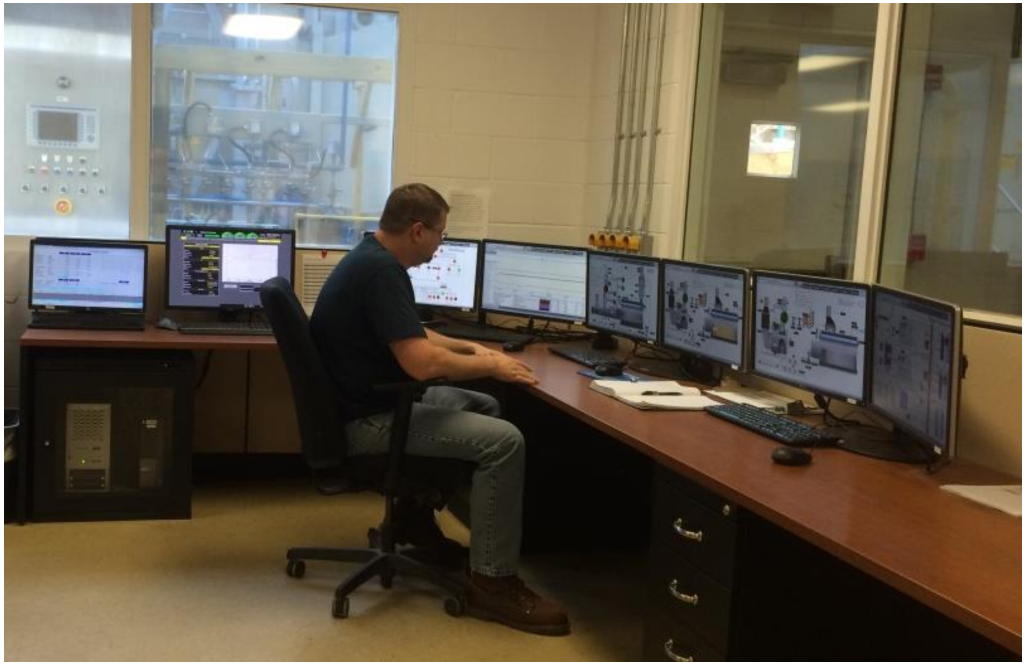
Major Equipment

- Two (2) Package Boilers – inside:
  - Natural gas-fired
  - Capable of 80 kpph each
  - MAWP: 375 psig
- BOP – outside, unless noted:
  - Natural gas compressor
  - 750 kW black start diesel generator
  - Switchgear – inside
    - New for CHP facility and upgrade to existing customer switchgear
  - Boiler feed-water system – inside
  - Condensate tank and forwarding pumps – inside
  - City make-up water treatment and storage:
    - Three (3) water softeners – inside
    - Two (2) RO units – inside
    - Two (2) 30,000 gallon treated water storage tanks

Operation Staff and Facilities

- Operations staff consists of:
  - Four (4) operating crews with two (2) O&M technicians on each crew
  - One (1) O&M lead technician
  - One (1) plant manager

- Facilities include:
  - Control room with visual on major equipment
  - Maintenance shop
  - Separate climate-controlled switchgear and IT rooms
  - Plant manager's office



Initial Operations Philosophy

- Power Supply
  - GT will be set on import control with level set to import <100 kW from utility
  - GT will load follow as necessary if plant requirements drop below GT available capacity at a specific moment
  - Upon GT loss, utility will supply all power
  - Upon utility loss, GT will island and load shedding at plant will commence, as necessary
  - Upon failure to island from utility, the diesel generator will provide power to black start the GT
  - Boilers will not be backed up by diesel generator

Initial Operations Philosophy

- Steam Supply
  - HRSG will supply all steam with boilers in warm standby (lower drum heating coils)
  - Upon GT loss, HRSG will automatically switch to fresh air firing and a backup boiler will be brought up, as necessary
  - Upon loss of HRSG, both boilers will be brought online
  - Main steam pressure at plant header will be maintained at ~325 psig
- Water
  - Upon loss of city water, water storage tanks will be utilized
  - If city water outage is expected to be longer than 12 hours, water trucks will be brought in and treated via softeners only (bypass RO)

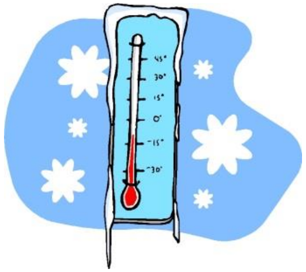
Goals and Challenges

- Target CHP facility availability of ***96%*** with ***NO*** steam events
- During start up and the first 6 months of operations, operational issues were experienced that could be categorized as follows:
  - Start-up and equipment set-up issues
  - Design and operating philosophy issues
  - Operator learning curve or knowledge transfer issues
- Outages first 6 months:
  - CHP facility availability – 87%
    - 12.5% unscheduled outages, 0.5% scheduled
  - Steam Pressure below 265 psig
    - 8 events

DTE Energy

Start-up and Equipment Set-up Issues

- Some causes of start-up and equipment set-up issues included:
  - Aggressive schedule and customer's desire to shut down temporary boilers asap
  - Staffing changes in commissioning and construction management teams resulted in lack of ownership of turnover process, system approvals, and punch list monitoring
  - Inefficient operator on-boarding during start-up – four (4) operators continued to operate customer's temporary boilers full time
  - Start up occurred during a very cold winter – weatherproofing was put to the test and needed to be improved during start up



Start-up and Equipment Set-up Issues

- Equipment trips due to controls issues included
  - HRSG SIL 2 controls: several HRSG trips due to the minimum position switch on the gas control valve having discrepancy failures – modified by OEM to decrease boiler events
  - Package boilers were set to trip on high water to avoid carryover – carryover is a lesser concern to the facility than a boiler trip so this was disabled
  - Gas compressor aftercooler set by OEM to turn on at gas high temp set point and remain on until compressor was shut down, this caused gas to get too cold and icing in GT fuel system, accounting for 117 hr of downtime – controls have been modified
  - Low temperature alarm on the gas turbine fuel system set too high – adjusted temp
  - Boiler BMS designed with a purge time of 8 minutes from start to release to modulate – purge time was lowered to 3 minutes
  - GT island mode controls settings caused a GT trip in island mode due to the T5 temperature set point in island mode being higher than the trip point – adjusted settings
- Boilers needed to be re-tuned due to high air flow – this made a 8:1 turn down impossible and caused issues when trying to light the boilers

Start-up and Equipment Set-up Issues

- GT tuning during cold weather resulted in a fuel-rich engine in warmer weather – due to IT issues, remote monitoring was not being done by the OEM at the time
  - 176 hr of CHP down-time was from this event
  - OEM was very responsive which helped minimize the downtime

Start-up and Equipment Set-up Modifications and Lessons Learned

- Lessons learned:
  - Do not rush system check-out, walk down, and start-up – doing a thorough job will reduce downtime after startup
  - Make sure the roles and responsibilities of the constructor, start up team, and vendor are clearly defined and understood
  - Discuss the factory set points with the OEM – make sure it is understood what will cause the equipment to trip, question the settings if they seem too stringent, unnecessary, or incorrect for your application
  - Hire an experienced controls integrator and verify their capability to do comprehensive factory acceptance testing
  - Assuming it is part of the project scope, insure that remote monitoring capability of the GT is fully functional at commercial operations

Design and Operating Philosophy Issues

DTE Energy

- Design and operating philosophy issues that came to light after startup included:
  - Heat tracing and freeze protection was inadequate
  - Several panels on the plant mezzanine were in an area where the temperature was higher than the panel's rated capacity – panel coolers were installed
  - Electrical system was modified to allow the boilers to be run off the diesel generator
  - CHP facility could not maintain 325 psig steam header due to a customer safety valve setting – pressure was reduced to 305 psig
  - Boilers were not able to ramp up quickly enough from warm standby, so operations protocol was modified to run one boiler at minimum turndown

Design and Operating Philosophy Modification and Lessons Learned

DTE Energy

- Lessons learned:
  - Allow flexibility in how you are able to operate your equipment and be realistic about how equipment and operators can respond during upset conditions
  - Budget for the appropriate contingency for CHP facility modifications AFTER startup due design “shortcomings”
  - Enclose as much critical equipment and instrumentation in weatherproof enclosures as possible – do not underestimate what may freeze
  - If the project is not turn-key, do a thorough review of the construction package prior to bidding – errors are cheaper to fix on paper, consider hiring a independent engineer to review if resources are not available to do this internally

Operating learning curve and Knowledge Transfer Issues

DTE Energy

- Work done during development, engineering, construction, and start-up had not being transferred efficiently to the operations personnel in all instances causing some confusion during unplanned events on site
  - Operators were brought on just before start-up and were trying to absorb a lot of information quickly
  - How to respond to loss of city water was not clearly communicated to the operations personnel
  - Functional description was not written with enough detail, so it was as not helpful to the operations personnel
  - Standard operating procedures were not fully customized for the site prior to start up

Operator Learning and Knowledge Transfer Lessons Learned

DTE Energy

- Lessons Learned
  - Onboard operators and plant manager as early as economically feasible – utilize operations personnel for operability reviews and start-up support
  - Consider assigning a plant system to each operator as his primary focus to allow the operators to cross train over time
  - Customize standard operating procedures prior to operations and include procedures for any planned upset condition
  - Specify that the controls integrator write a detailed functional description for the systems – begin this activity early and push for a high quality finished product

Good News

- After working through these initial project issues availability has increased significantly:
  - Outages during last 5 months of 2015:
    - Cogen – 96% availability
    - 1% unscheduled, 3% scheduled
  - Steam pressure below 265 psig
    - 1 event
  - Outages during first 5 months of 2016:
    - Cogen – 97% availability
    - 0.8% unscheduled, 2.2% scheduled
  - Steam pressure below 265 psig
    - 3 events

- No environmental events and zero OSHA recordables since mobilization at the site in November 2014

Work in Progress

- DTE Marietta is still working to optimize the plant, including:
  - Simulating outage events to optimizing response time
  - Reviewing equipment in hot plant areas and modify HVAC systems
  - Studying power quality to determine if power quality has caused any of the controls issues
  - Reviewing, modifying, or creating, as necessary, standard operating procedures
  - Working with customer to increase steam header pressure to allow more boiler response time during GT-HRSG outages and verifying steam pressure at the process during short duration pressure losses at the CHP facility

Summary

- Start-up was challenging, educational, and rewarding
- DTE Marietta plant operations and DTEES home office engineering and operations team worked together to address issues as they came up
- DTEES SME's assisted with solutions and maintained constant contact with the facility design engineer and equipment OEM's to work through any issues until an acceptable resolution was reached
- CHP facility received answers/solutions quickly which allowed the facility to overcome many obstacles
- Maintained regular communication with the customer to apprise them of the issues and their resolutions

DTE Energy

Any questions?

Mike Larson
Director, Business Development
414 S. Main Street, Suite 600
Ann Arbor, MI 48104
734-353-0537

Mary McVeigh
Development Engineer
414 S. Main Street, Suite 600
Ann Arbor, MI 48104
734-277-4910

www.dtees.com