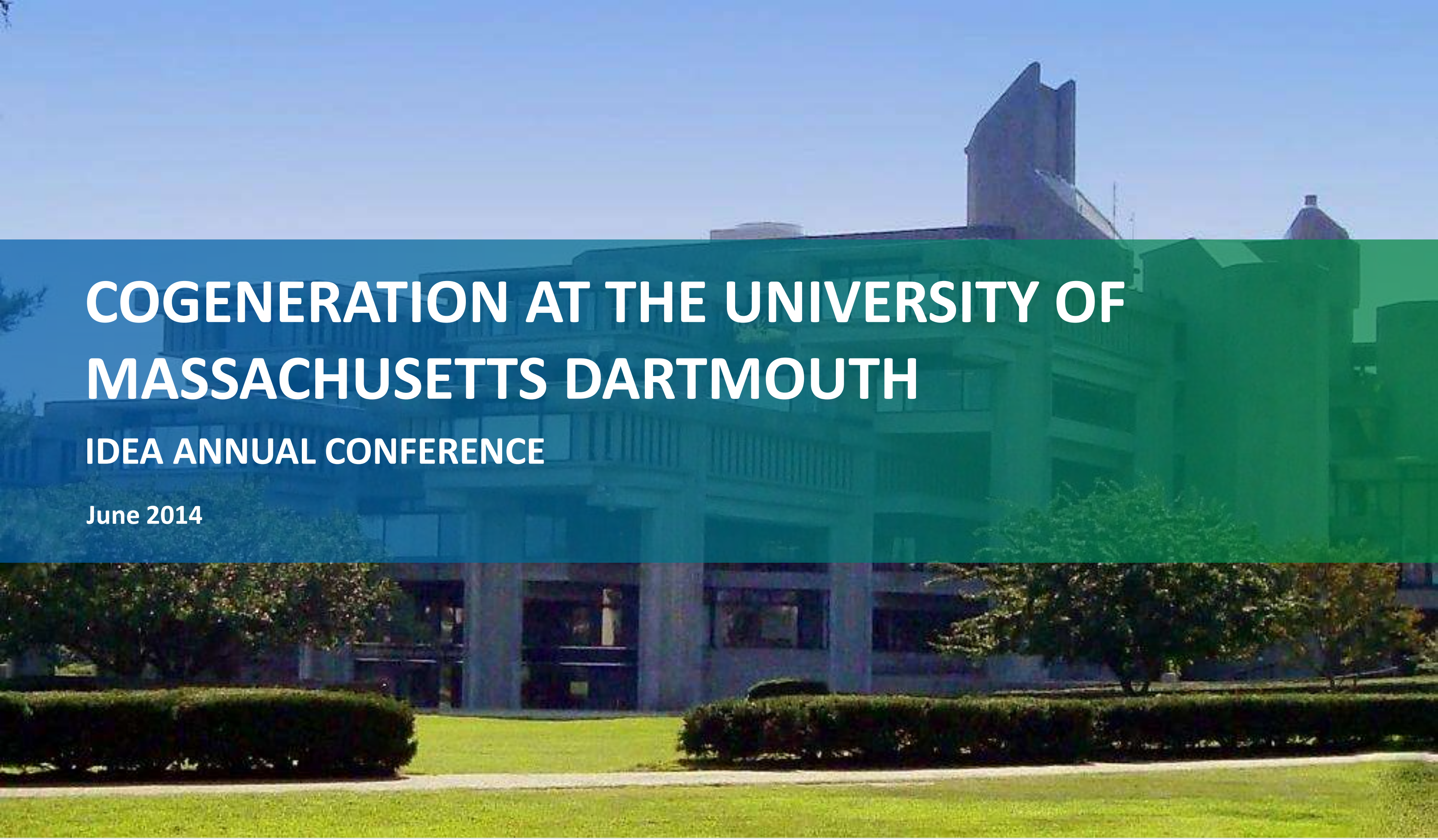


COGENERATION AT THE UNIVERSITY OF MASSACHUSETTS DARTMOUTH

IDEA ANNUAL CONFERENCE

June 2014

NORESCO

United Technologies

AGENDA

- Project summary
- Design approach
- Implementation approach
- Lessons learned
- Discussion

PROJECT HIGHLIGHTS

PROJECT COST
$33.9 million

CONTRACT TERM
20 years

EFFICIENCY MEASURES

- New gas turbine with heat recovery steam generator
- HVAC modifications & base mechanical system upgrades
- Building control systems
- Water conservation retrofits
- Lighting upgrades & controls
- Electric & steam sub-metering
- Weatherization

$2.9M
Annual cost savings

18,359,224
kWh reduction in grid-electricity usage

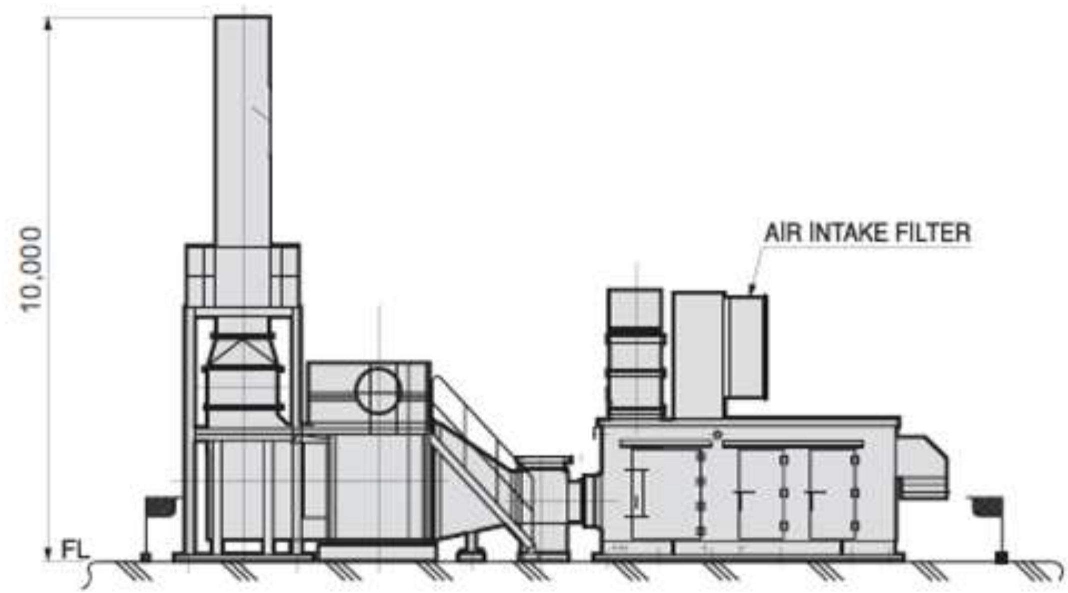
27% CO_2

31% SO_x

55% NO_x

Utility-related footprint emissions reductions

COGENERATION PLANT HIGHLIGHTS



- New 1.6 MW gas turbine with heat recovery steam generator (HRSG)
- Ammonia selective catalytic reduction (SCR)
- Natural gas compressor

COGENERATION PLANT CHALLENGES

Operate efficiently over a wide range of output to meet large load fluctuations

Meet stringent Massachusetts air emission limitations

Integrate into an existing boiler house with very little available space

DESIGN AND SIZING APPROACH

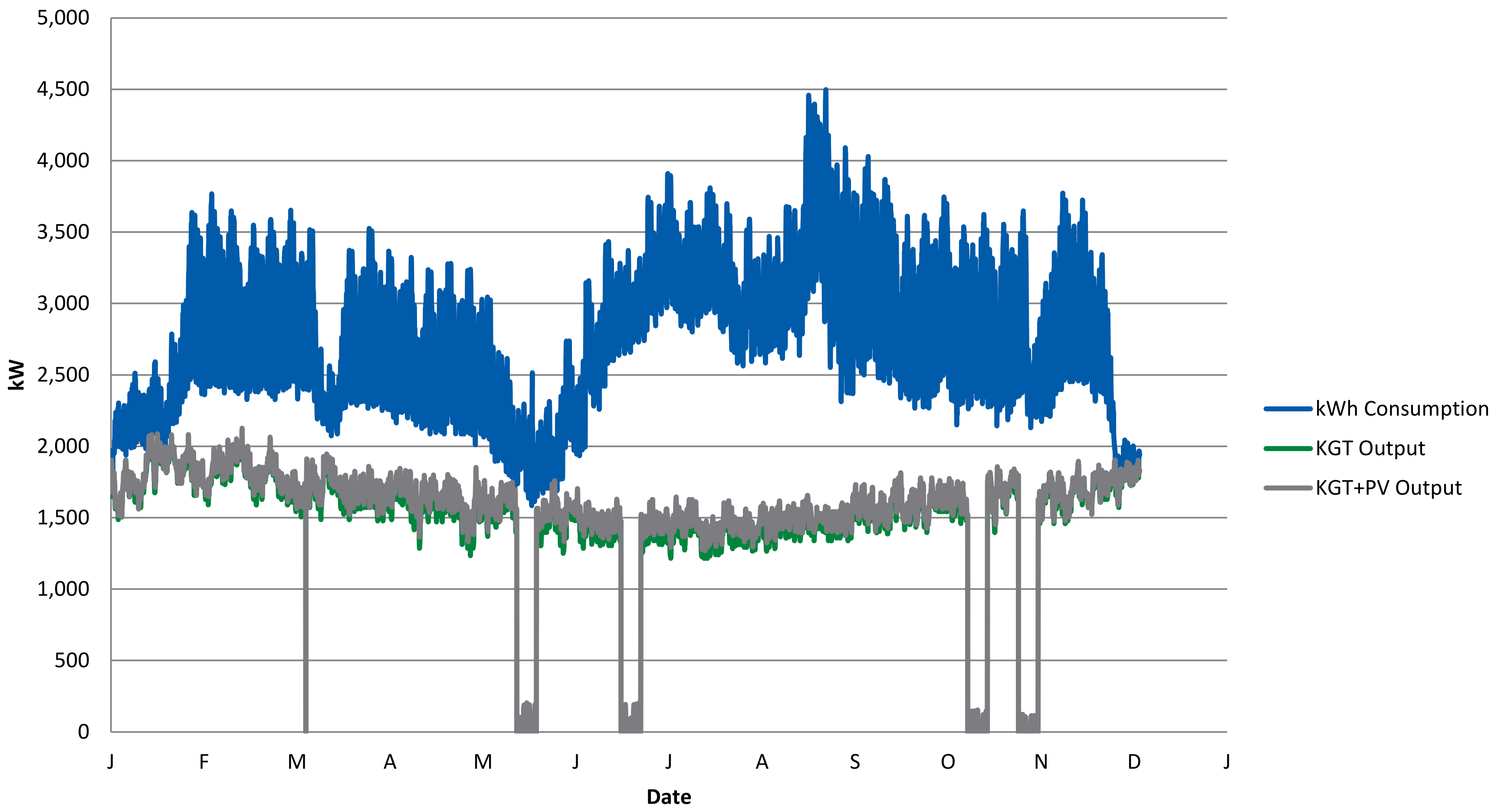
DESIGN & SIZING

STEPS TAKEN

- Reviewed existing steam and electric loads
- Determined paybacks for multiple sizes and technologies using hourly historical data with Excel spreadsheet models
- Reviewed with customer wants and needs
- Customer required more thermal therefore a gas turbine was selected
- Reviewed preliminary air emissions limitations for feasibility

LOAD ANALYSIS

Electric demand profile



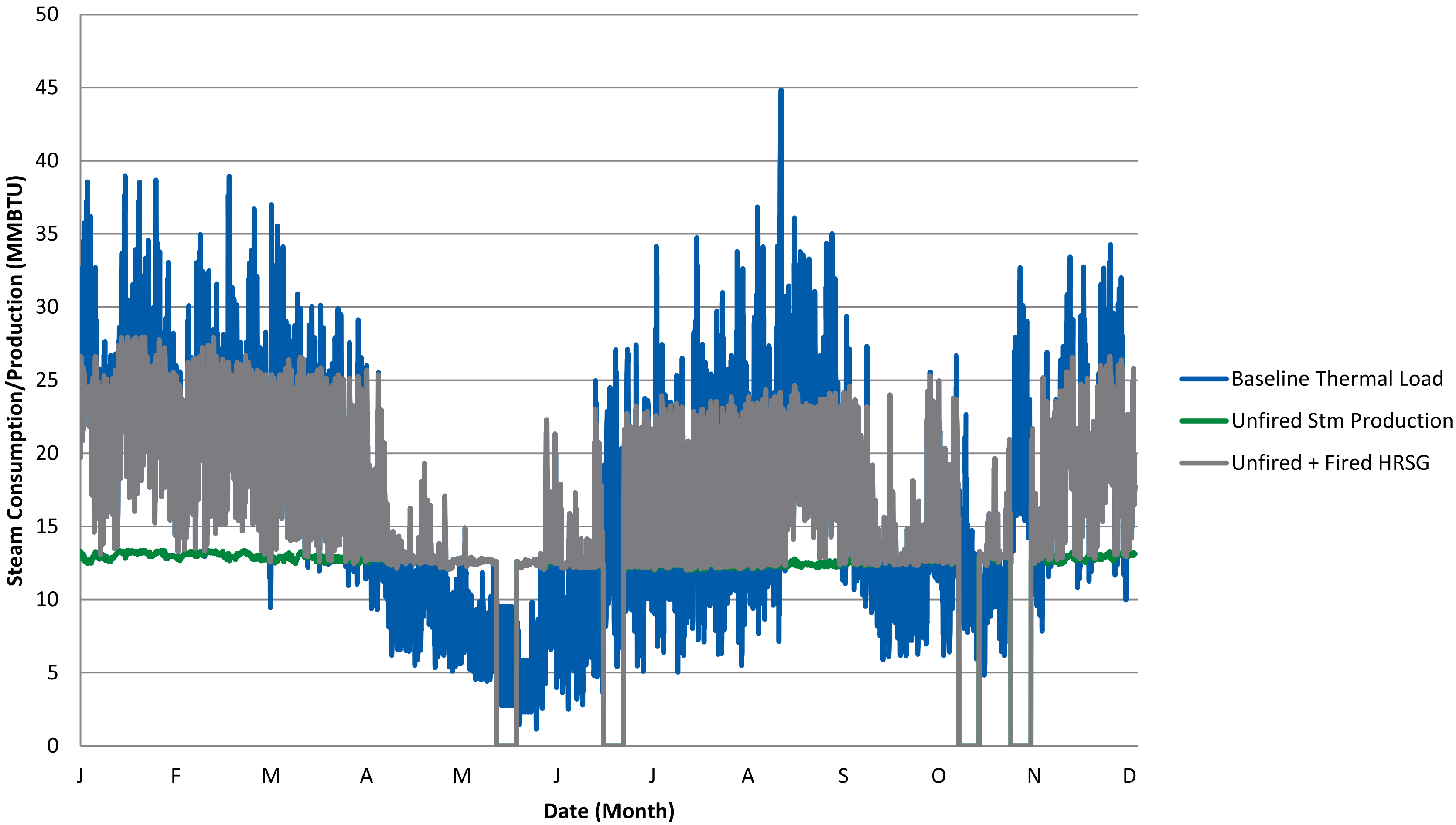
Electrical output is less than the campus needs

HRSG CAPACITY

- HRSG unfired steam capacity 12,000 lbs/hr of steam
- HRSG duct fired steam capacity 24,000 lbs/hr of steam
- Steam dump condenser capacity for 12,000 lbs/hr of steam

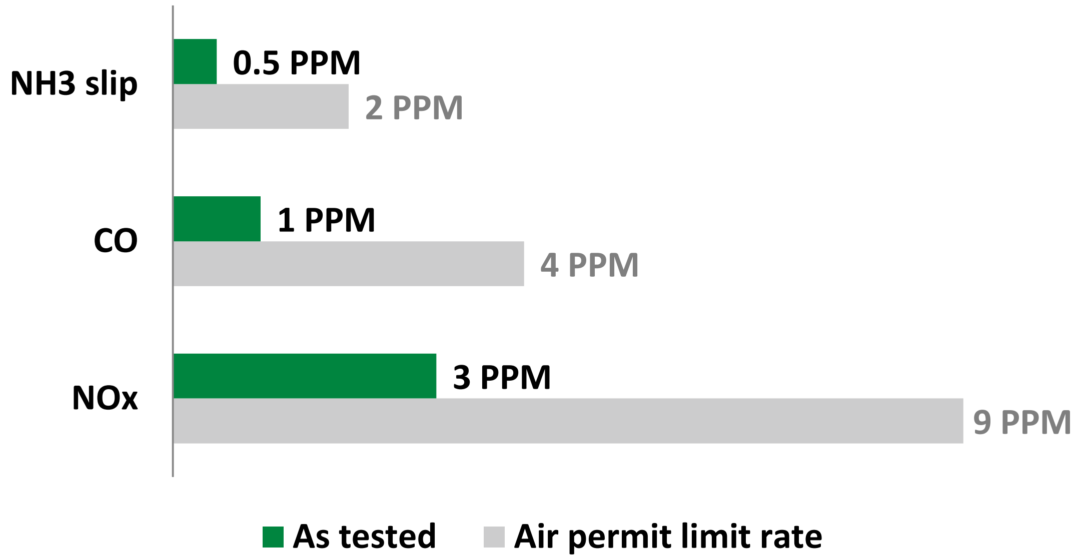
LOAD ANALYSIS

Steam demand profile



HRSG steam output exceeds shoulder month and summer night requirements therefore some heat is required to be rejected at these times

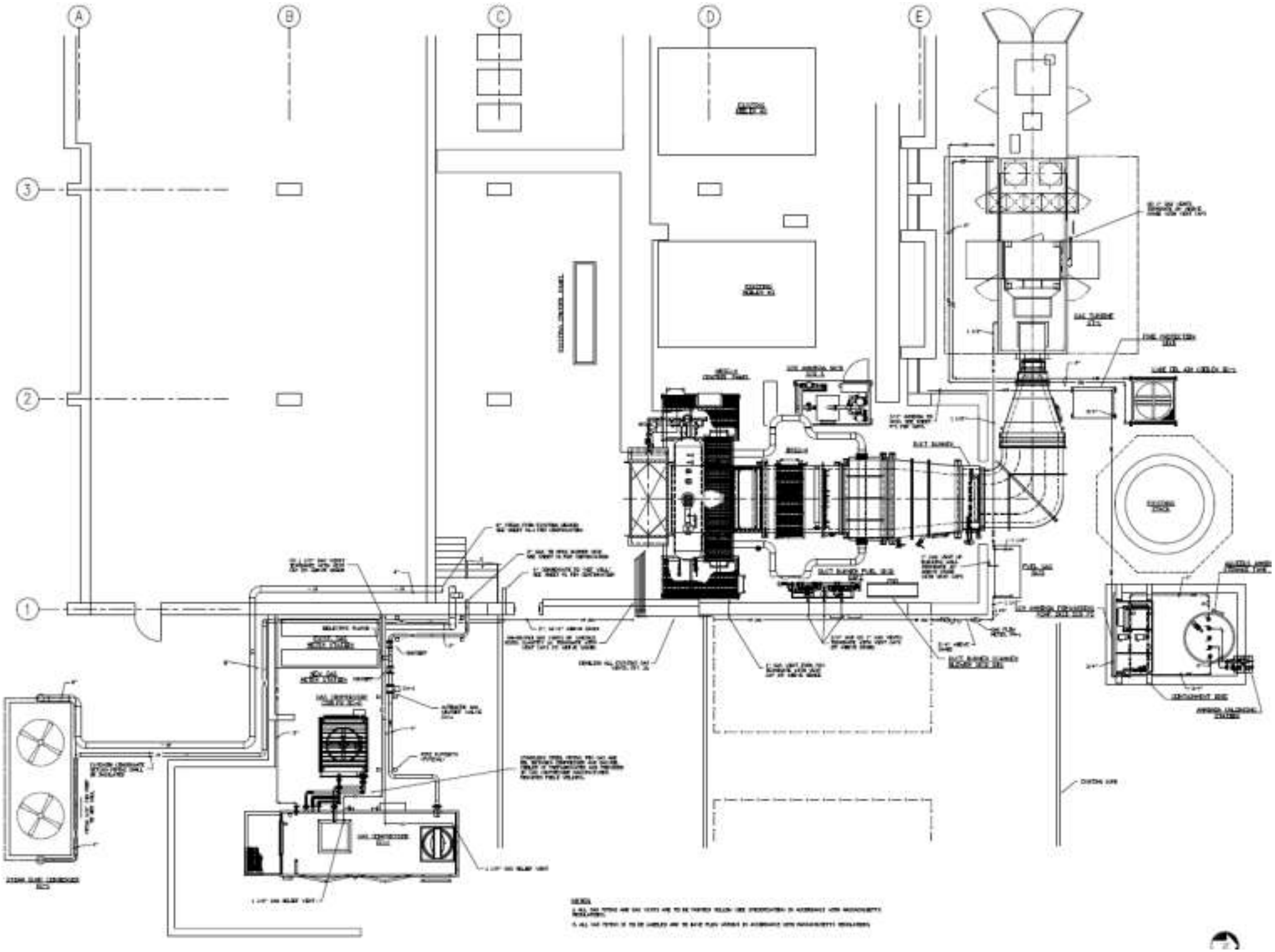
MEETING EMISSIONS STANDARDS



- Ammonia SCR was required in the order to meet the NOx emission limit
- CO catalyst was required to meet the emissions requirement - turndown to 80% load was achieved with the catalyst

IMPLEMENTATION APPROACH

PLANT LAYOUT



HRSG PHOTOS

Left Side of HRSG

Right Side of HRSG

MORE EQUIPMENT PHOTOS

Platform Access to Steam Drum

Gas Turbine

GAS TURBINE

GAS TURBINE

STEAM DUMP RADIATOR & PARAMETRIC EMISSIONS MONITORING SYSTEM (PEMS)

Steam Dump Radiator

PEMS

APCU SKID & HRSG LOCAL CONTROLS

LESSONS LEARNED

LESSONS LEARNED

- Designing for tight spaces should take into consideration maintenance access and code-required clearances. It adds cost and time to the design and installation.
- Usage of Ammonia SCR prompted some discussions about student, staff and employee safety.
- Rejecting steam through a radiator rather than install an additional SCR and bypass stack proved more economical because of the high cost of an additional stack, SCR and CO catalyst.

QUESTION & ANSWER

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