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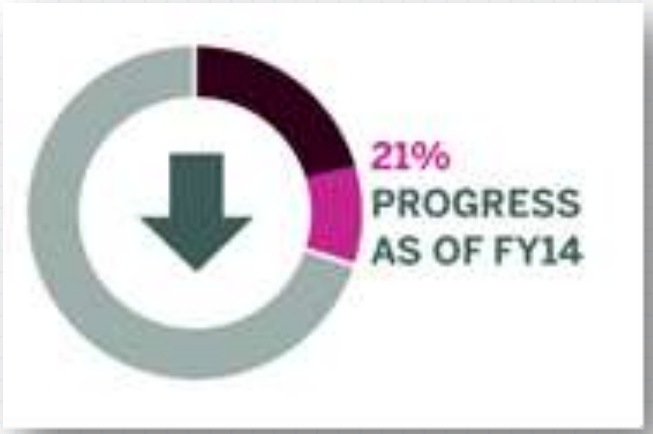
AIR PERMITTING CASE STUDY: HARVARD'S CHP EXPANSION

Overview

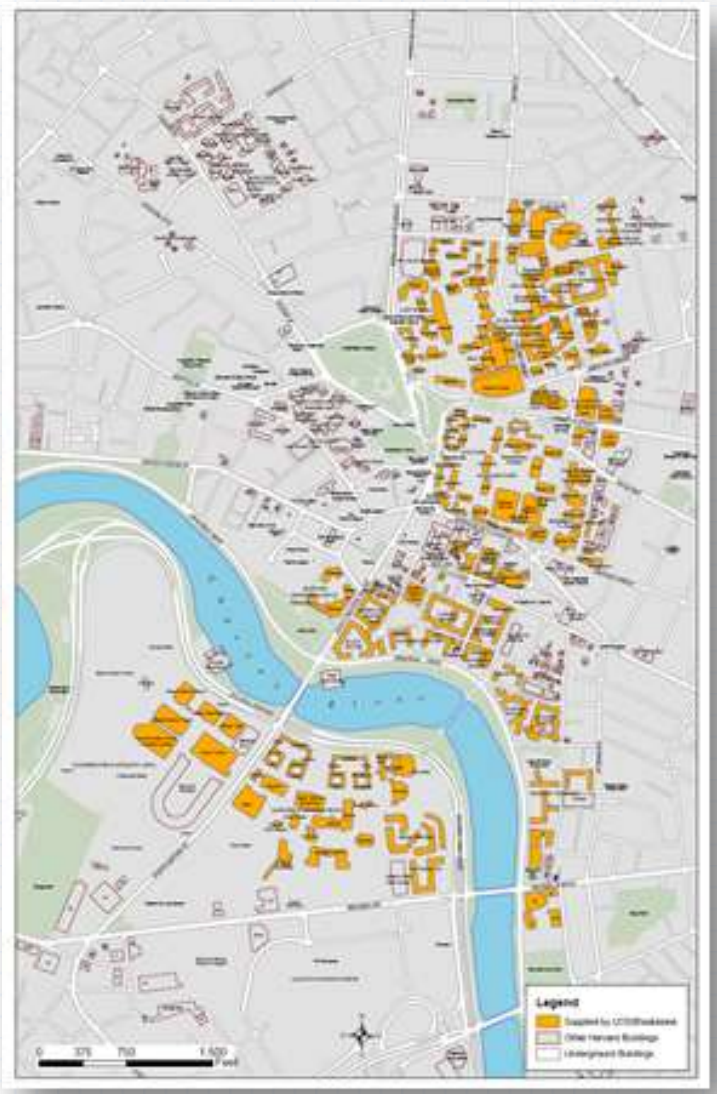
- Harvard University is expanding its CHP capability with a new 7.5 MW combustion turbine and fired HRSG.
- The project is the largest to-date to utilize special Massachusetts air permitting regulations designed to encourage CHP.
- The presentation will cover how the CHP regulations worked, and how Harvard developed the plant to maximize operating flexibility while protecting ambient air quality and streamlining the review process.

Harvard GHG Commitment

- In 2008, President Drew Faust, the Deans, and the Corporation adopted an ambitious short-term goal, based on the best available science, to reduce University-wide emissions 30% by 2016, including growth, from a 2006 baseline.

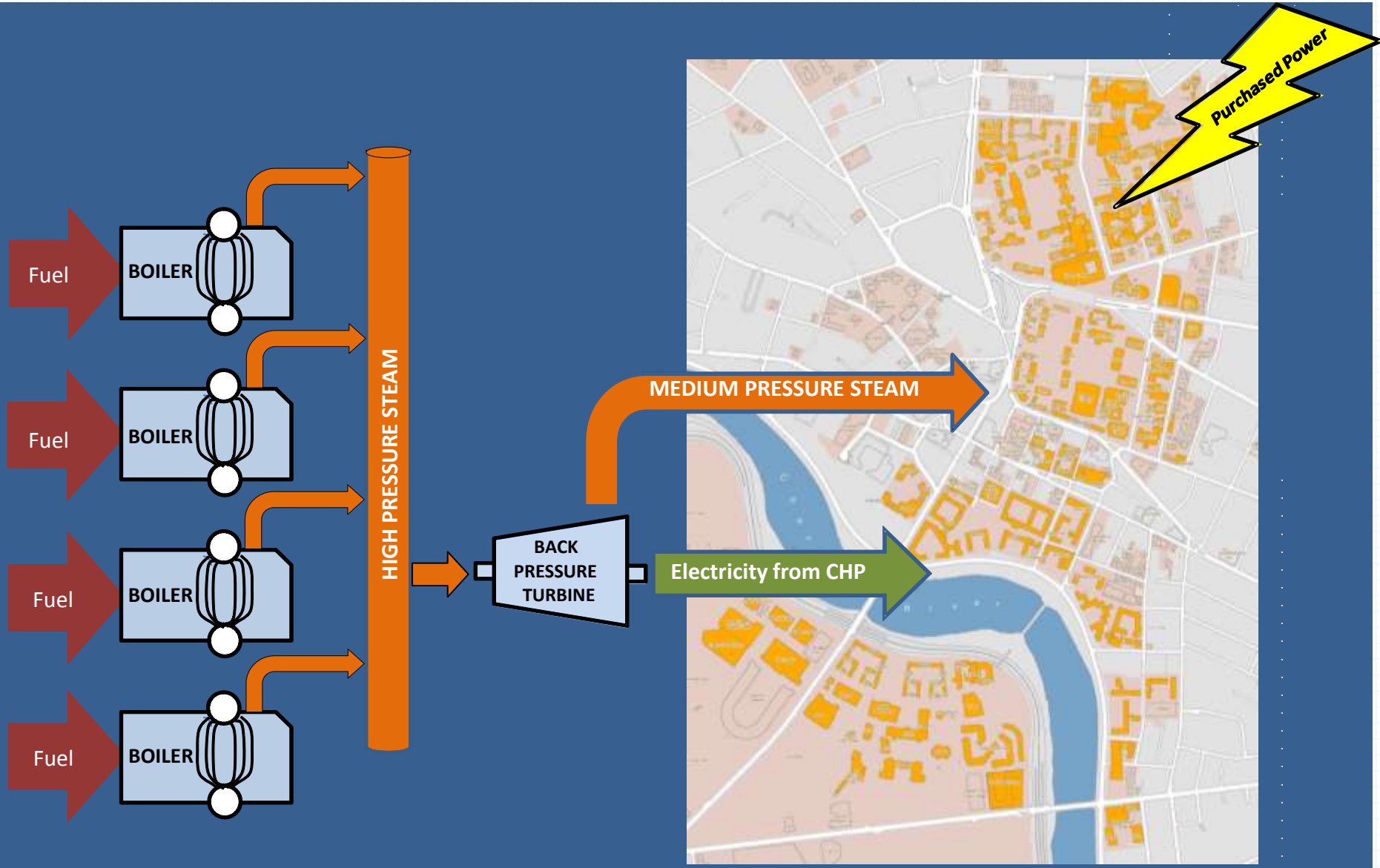


Blackstone Plant

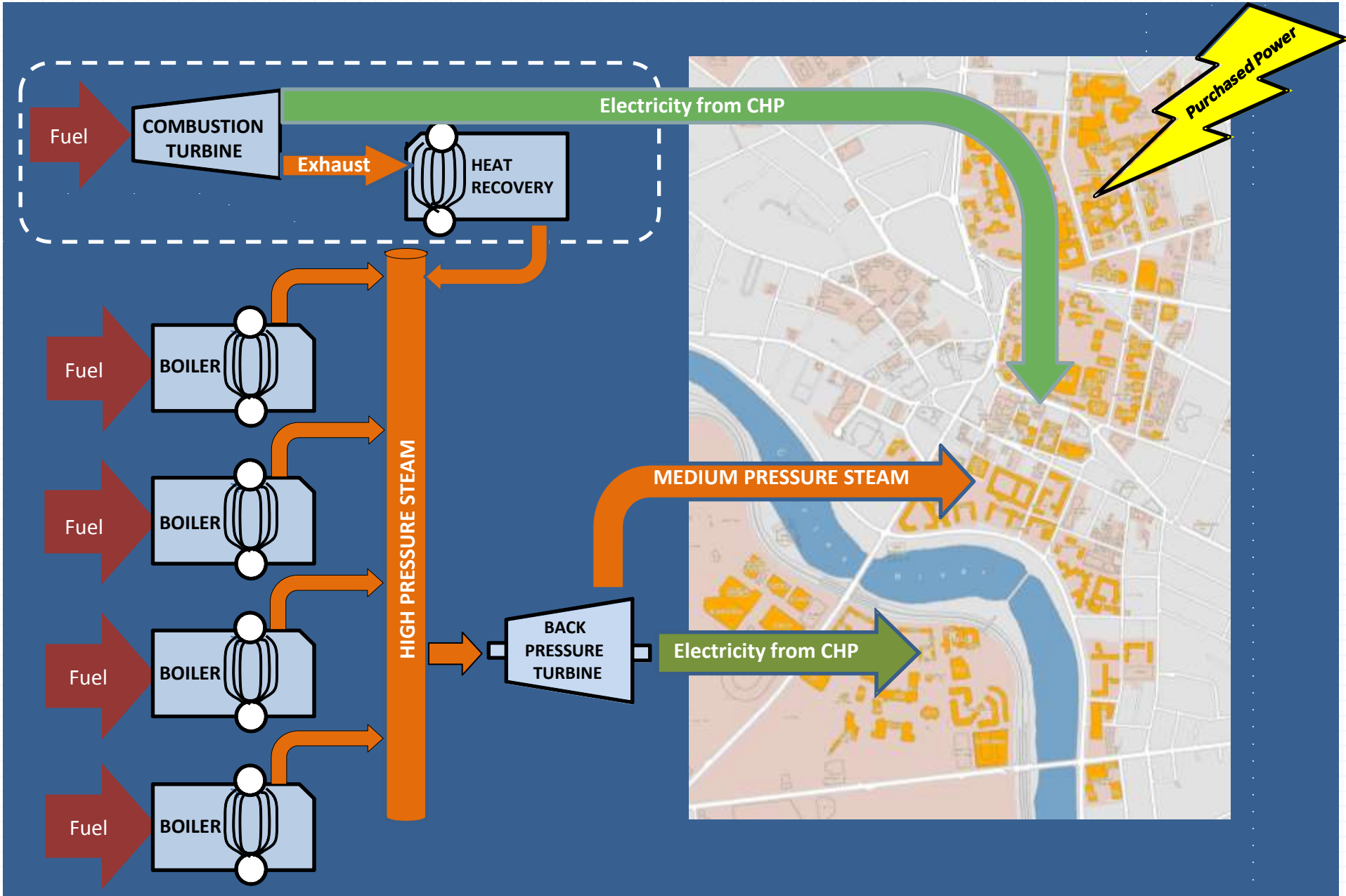


- Primary heat energy source to 160 Cambridge and Allston campus buildings (~11 million GSF).

Existing Blackstone Plant Configuration

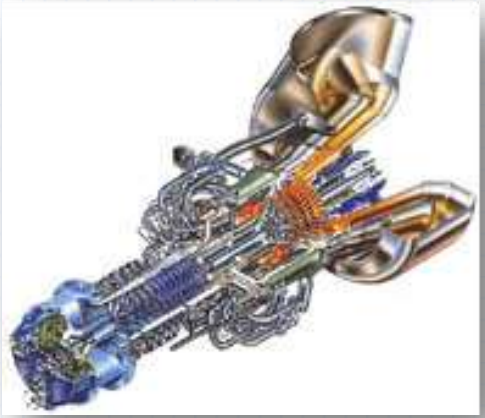


New Blackstone Plant Configuration



New Equipment

- Solar Taurus 70, HRSG with 51 MMBtu/hour duct burner



- See Prior Presentation for Turbine Selection

  (Combustion Turbine Selection and Optimization: Harvard University Blackstone CHP Expansion – Douglas Schmidt, Harvard Engineering & Utilities; Tom Parker, Burns & McDonnell)

- Natural Gas with Ultra-Low Sulfur Diesel (ULSD) backup

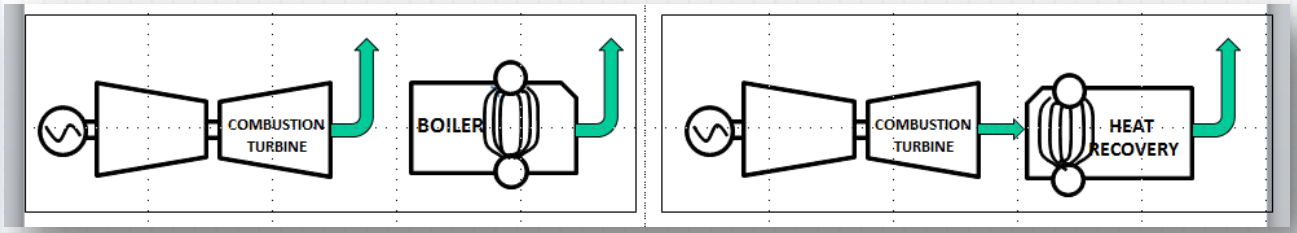
Pollutants and Controls

POLLUTANT	SOURCE	CONTROLS
Nitrogen Oxides (NOx)	High-temperature combustion of nitrogen in air	Selective Catalytic Reduction (SCR); uses ammonia to reverse the reaction
Carbon Monoxide (CO)	Incomplete combustion	Oxidization catalyst
Volatile Organic Compounds (VOC)	Incomplete combustion	Oxidization catalyst
Sulfur Dioxide (SO2)	Sulfur in fuel	Cleanest fuels
Carbon Dioxide (CO2)	Carbon in fuel	Cleanest fuels
Particulate Matter (PM)	Incomplete combustion, other sources	Cleanest fuels
Ammonia (NH3)	Unreacted reagent from SCR	SCR

- ***All pollutants are minimized through controlled combustion and efficient CHP service.***

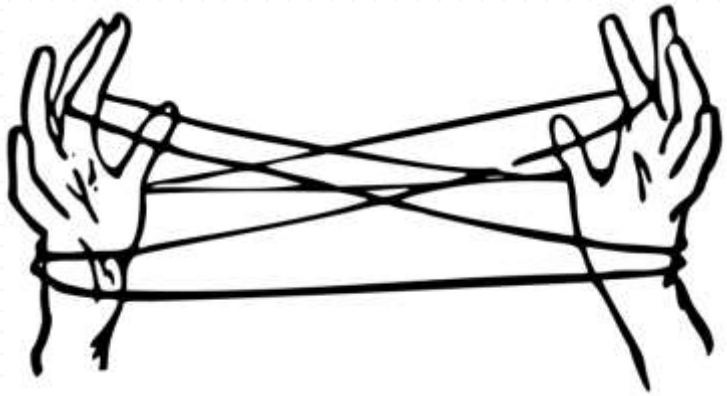
Massachusetts CHP Regulation Overview

- In March of 2008, MassDEP proposed regulations "to encourage the installation of CHP systems" because CHP systems "will reduce greenhouse gas and other emissions, reduce fossil fuel usage and enable cost savings."
- The regulations establish "a methodology that enables the applicant to adjust the emission limitation for a CHP system and take into account emissions that will not be created by omitting a conventional separate system (e.g. boiler) to generate the same thermal output."



Massachusetts CHP Regulatory Details

- The CHP regulations were promulgated as 310 CMR 7.26(45), which in-turn references the Environmental Results Program (ERP) pollutant-specific emission limits in 310 CMR 7.26(43).
- So, the CHP expansion can satisfy the plan approval requirement in 310 CMR 7.02(5) to meet Best Available Control Technology (BACT) as defined in 7.02(8)(a)2 by meeting the 7.26(43) limits with the assistance of the 7.26(45) credits.



Massachusetts CHP Regulatory Calculation Details

$$\text{Credit lbs/MWh}_{\text{emissions}} = \frac{\text{(boiler limit lbs/MMBtu}}{\text{boiler efficiency)}} \times \frac{\text{3.412 MMBtu/W}_{\text{thermal}}}{\text{(power-to-heat ratio)}}$$

- While Blackstone has an existing thermal system, Harvard proposes to only take credit for the hypothetical emissions that would be generated by a new natural-gas boiler – boiler efficiency 80% per CHP regs.
- Power-to-heat Ratio means the design electrical output divided by the design-recovered thermal output in consistent units of measurement.
- Maximum unfired heat recovery in HRSG is 10.2 MW (at 7.4F ambient temperature). CTG electric output at the same conditions is 8.89 MW. Power-to-heat ratio is 8.89/10.2 = 0.872

Massachusetts CHP Regulatory Calculation Example - NOx

$$\text{Credit lbs/MWh}_{\text{emissions}} = \frac{\text{(boiler limit lbs/MMBtu}}{\text{boiler efficiency)}} \times \frac{\text{3.412 MMBtu/W}_{\text{thermal}}}{\text{(power-to-heat ratio)}}$$

$$\frac{0.035 \text{ lbs NOx/MMBtu*}}{80\%} \times \frac{3.412 \text{ MMBtu/MWthermal}}{0.872} = 0.171 \text{ lb NOx/MWh emissions}$$

* based on 310 CMR 7.26(33)

Turbine NOx during natural gas firing	0.14 lb/MWh (ERP limit) + 0.171 lb/MWh (CHP credit) = 0.311 lb/MWh
Turbine NOx during ULSD firing	0.34 lb/MWh (ERP limit) + 0.171 lb/MWh (CHP credit) = 0.511 lb/MWh

- ***(not enough to reasonably remove the SCR)***

Massachusetts Permitting Process

(j) Department Approval. Plan approval will be issued by the Department where:

1. The emissions from a facility do not result in air quality exceeding either the Massachusetts or National Ambient Air Quality Standards; and
2. The emissions from the facility do not exceed applicable emission limitations specified in 310 CMR 7.00; and
3. The emissions from the facility do not result in violation of any provision of 310 CMR 7.00; and
4. The facility does not require a plan approval pursuant to 310 CMR 7.00: *Appendix A* or the plan approval requirements of 310 CMR 7.00: *Appendix A* have been met by the application and a 310 CMR 7.00: *Appendix A* plan approval has been issued by the Department. The Department has the discretion to issue the 310 CMR 7.00: *Appendix A* plan approval in conjunction with a 310 CMR 7.02 plan approval; and
5. Reserved.
6. The emissions from such a facility or operation of such a facility represent the most stringent emission limitation as specified in 310 CMR 7.02(8); and
7. The owner or operator of the facility has made a demonstration of compliance required under 310 CMR 7.02(4)(d)5. or 310 CMR 7.02(5)(c)8.; and
8. The requirements of 40 CFR Part 63.40 through 40 CFR Part 63.44 are applicable and have been met and an approval has been issued as required by 40 CFR Part 63.40

Ambient Air Quality Analysis

Environmental Results Program (ERP)

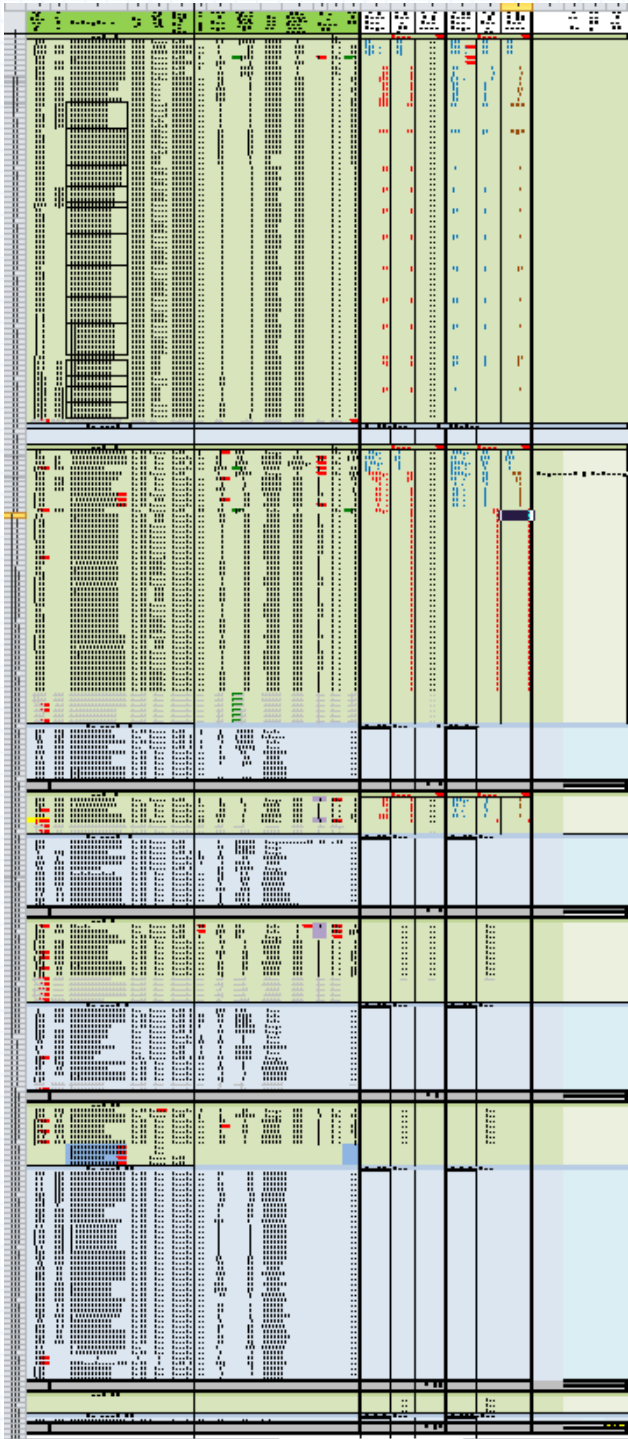
Noise Analysis

Non-Attainment New Source Review (NSR)

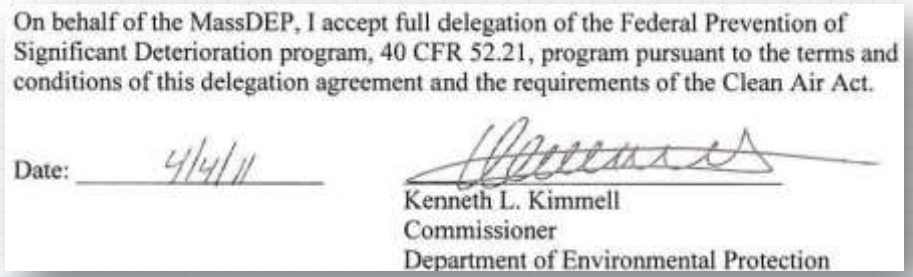
Best Available Control Technology (BACT)

New Source Review

- Triggered if NOx or VOC > 25 tons/year increase
- Campus-wide contemporaneous emissions increases & decreases
- Complicated tracking



Federal Permitting Process



On behalf of the MassDEP, I accept full delegation of the Federal Prevention of Significant Deterioration program, 40 CFR 52.21, program pursuant to the terms and conditions of this delegation agreement and the requirements of the Clean Air Act.

Date: 4/4/11

Kenneth L. Kimmell
Commissioner
Department of Environmental Protection

- Prevention of Significant Deterioration (PSD)
- EPA delegation agreement
- Additional modeling
- Longer timeline (~1 year instead of 96 days)
- Additional appeal path

Streamlining: PSD Applicability

	CHP & Duct Burner future potential, tons/year	PSD Significance Threshold, tons/year	Significant?
NOx	7.6	40	No
CO	10.3	100	No
VOC	8.2	40	No
SO2	1.7	40	No
CO2	69,600	75,000	No

- Options to net out of PSD
- "Significant emissions increase" "Significant net emissions increase" "Actual-to-projected-actual applicability test" "Actual-to-potential test" "Hybrid test"

Particulate Matter Emission Rate

- Filterable versus condensable
- Stack testing uncertainty
- Additional effort working with vendor
- Vendor guarantee improvement

	CHP & Duct Burner future potential, tons/year	PSD Significance Threshold, tons/year	Significant?
PM10	9.8	15	No
PM2.5	9.8	10	No

Air and Noise Modeling

- Air quality dispersion modeling showed that emissions from the entire Blackstone Plant will not result in air quality exceeding the Massachusetts or National Ambient Air Quality Standards.
- Air modeling was done for different stack configurations to allow flexibility in the final design.
- Noise modeling showed compliance with MassDEP noise guidance.

Permit Conditions and Approval Process

- Harvard proposed to use the CHP regulation credits when calculating proposed short-term emission limits, but continue to comply with stricter top-case BACT for long-term limits.
- This approach allows resiliency and flexibility during transient and upset conditions, while achieving best available emission rates over the long-term.
- MassDEP allowed use of the CHP credit only for pollutants specifically listed in the reg (no VOC).

Permit Conditions and Approval Process

- For simplicity of compliance, Harvard requested and received emission limits on a pounds/hour basis for natural gas and ULSD firing.
- Compliance using Continuous Emissions Monitoring Systems for NOx, CO, NH3, opacity.
- Initial stack testing for VOC, annual stack testing for PM (can be reduced after 5 years).
- No short-term limits during startup, but have to test and include emissions when complying with annual limits.

Conclusions

- Using the MassDEP CHP regulation allows a credit towards some emission limits.
- Costs of add-on pollution controls cannot reasonably be avoided.
- Harvard installed Best Available Control Technology, and used the CHP regulation only for short-term operating flexibility.
- The MassDEP CHP regulation does not eliminate other requirements (NSR, PSD, air & noise modeling).

Sources & References

Slide 3: Greenhouse Gas Reduction Goal, http://green.harvard.edu/topics/energy-emissions/greenhouse-gas-reduction-goal

Slide 7: Taurus 70 PG - Generator Set, https://mysolar.cat.com/cda/layout?m=41104&x=7

Slide 9: Background Information Document And Proposed Amendments to 310 CMR 7.00, Engines and Combustion Turbines, Combined Heat and Power, March 2008

Slide 10: 310 CMR 7.26(45); 310 CMR 7.26(43); 310 CMR 7.02(5); 7.02(8)(a)2; and email correspondence with Marc Wolman, MassDEP, 10/3/2012

Slide 11: 310 CMR 7.26(45)

Slide 13: 301 CMR 7.02(3)(j)

Slide 15: Agreement for Delegation of the Federal Prevention of Significant Deterioration (PSD) Program by the United States Environmental Protection Agency, Region I to the Massachusetts Department of Environmental Protection, March 2011

Slide 16: 40 CFR 52.21

Slide 20: Non-Major Comprehensive Plan Approval: Harvard University - 10/29/2013, http://www.mass.gov/eea/agencies/massdep/air/approvals/air-permits-and-approvals-issued-to-facilities.html

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