Senior Thesis Program AE 481-COMPREHENSIVE SENIOR PROJECT I
Building Mechanical & Energy Systems Option

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Summary
These assignments will help you to gain a thorough understanding of the mechanical systems in your building and to generate ideas for the AE 482 project. The AE 481 Mechanical systems grade will be based on the following submittals (note due dates):

Technical Report 1: ASHRAE Standard 62.1 and Standard 90.1 Evaluation 9/18
Technical Report 2: Building and Plant Energy & Emissions Analysis 10/1
Technical Report 3: Mechanical Systems Existing Conditions Report 11/11
AE 482 Mechanical systems project proposal 12/13

Policies

Grading

Due dates established by course coordinators are firm. Deliverables are to be submitted in hard copy to your Mechanical Systems Faculty member, either in person or to their mailbox in 104 Engineering Unit A.

Penalties for late submissions and permission to resubmit late submissions for regrading will be administered per the policy established by the AE 481 Coordinators. The final Mechanical Systems mark will be based on the weighted average of submittal grades as follows:

Specific requirements for each submittal follow.
ASHRAE Standard 62 report 26.67 %
Building and Plant Energy & Emissions Analysis Report 26.67 %
Mechanical systems existing conditions report 26.67 %
AE 482 Mechanical systems project proposal 20.00 %

Submittal Requirements

Each submittal shall be in the form of a concise summary report with supporting documentation attached in appendices. The report should begin with a 1-2 page executive summary that states key conclusions as succinctly as possible followed (if needed) by more extended narrative. Identify your building, state the purpose of the report, review relevant building characteristics, and then give your analysis and findings. Submittals shall be prepared in a professional manner: 8-1/2 x 11 format, logically organized and legible (summary typed, hand calculations and sketches neatly lettered/drawn). Every submittal must include your name and the name and location of your building.

Technical Report 1: ASHRAE Standard 62.1 Ventilation and Standard 90.1 Energy Design Evaluations

ASHRAE Standard 62.1establishes minimum requirements for outside ventilation air in buildings. ASHRAE Standard 90.1 establishes minimum requirements for energy performance design. Copies of both will be on the AE Y drive.
The assignment has three main tasks:

1. Review your building's compliance with the systems and equipment requirements in section 5 of Standard 62.1. This covers a number of important issues such as measures to prevent mold growth, measures to prevent re-entry of contaminated air, and particulate filtration.
2. Use the Ventilation Rate Calculation Procedure (Section 6) of Standard 62.1 to determine whether your building meets ventilation and exhaust requirements at design conditions. Use the mechanical plans and schedules to obtain the design airflow to each space.
3. Evaluate the degree of your building's compliance with the building envelope, HVAC systems, service water heating, power, lighting, and electric motor efficiency) criteria of ASHRAE Standard 90.1.

Report requirements:
Standard 62.1 evaluation

• Summary of compliance with section 5 requirements

• Ventilation Rate Procedure Analysis

Discussion of which systems were selected for analysis and why (if you did not analyze your entire building).

Summary of compliance with Ventilation Rate Procedure. Discuss any systems for which your calculations resulted in values significantly lower or higher than values found in design documents.

Discussion of any problem or opportunity areas identified by your analysis

Spread sheet table(s) of space characteristics (area, use, design occupancy) for each space evaluated (in Appendix) [Note: It may be possible for you to combine this item and the following two in a single table.]

Spread sheet table(s) of outside air requirements by space for each system evaluated (Appendix)

Summary of Z_P values for each space. Identify Max (Z_P) for each system. (Appendix)

Comparison of nominal outside air (Σv_{oz}) and. required outside air (v_{ot}) for each AHU evaluated and for the entire building

Supporting calculations

Standard 90.1 evaluation

• Summary of compliance with prescriptive requirements of the standard

• Discussion of components or systems that significantly exceed or fall short of prescriptive requirements, if any.

For non-compliant systems, whether compliance was achieved by a different path (for example, whole-building performance via the Energy Cost Budget method of Chapter 11), if that information is available from the designer or owner.

For components significantly exceeding requirements, was this done for the purpose of trade off with other components (for example, more efficient HVAC to compensate for large glazed area), or for other reasons.

Technical Report 2: Building and Plant Energy Analysis Report

This report should demonstrate your clear understanding of building HVAC load and energy analysis procedures. Perform block load and energy estimates using a computer-based method. Any whole building load and energy simulation program (e.g. EnergyPlus, eQuest, Trace, HAP, IES, ASHRAE RTSM followed by energy analysis of specific equipment configurations) that can estimate the design load, annual energy consumption and operating costs of your project building can be may be used. You are to construct the model yourself. IT IS NOT ACCEPTABLE TO RUN A MODEL OF YOUR BUILDING PREVIOUSLY PREPARED BY SOMEONE ELSE THAT YOU DID NOT DEVELOP. By applying

typical block load procedures to the development of your model, you should be able to get a reasonably accurate estimate in return for a reasonable level of effort.
Report Requirements;

• Design load estimation

Estimate and report the design heating and cooling loads based using actual data taken from the design documents.

Use the OA ventilation rates from the design schedules (not the results of your Std. 62 analysis)

Use lights and equipment electrical loads on a W/sq-ft basis

Use design occupancy also from the design documents (if available)

Use design indoor and outdoor air conditions for heating and cooling for your building location from the ASHRAE Handbook of Fundamentals 2009 (0.4% and 99.6%)

Provide description of load sources and schedules

Compare design document and computed load and ventilation indices (i.e. cooling ft_2/ton, heating Btuh/ft_2, total supply air cfm/ft_2, and ventilation supply cfm/ft_2)

• Annual energy consumption and operating costs

Estimate the annual energy consumption using the same ventilation rates, and internal generation and envelope as used in the load estimation portion.

Clearly specify the schedules, fuel costs (including demand), air and water flow rates, and equipment performance characteristics that you used.

Check with your building design engineer to determine if an energy analysis was performed on your building. . If one was not performed, determine why the engineer chose not to do so.

If an energy analysis was performed by the engineer, report on the software used, and how the results compared to your analysis.

If actual utility bills/data are available compare actual energy use and modeled energy use for different load conditions should be made. Estimation of electric energy fractions of various building subsystems – HVAC, lighting, office equipment -is desirable to provide a basis for energy efficiency improvement claims of the redesign suggested in the thesis.

Break out the annual cost to operate the heating and cooling plants, air distribution fans, secondary equipment such as unitary heat pumps the lighting system, and miscellaneous equipment (customize this list as appropriate for your systems).Provide annual cost per square foot to operate the building and costs for major end uses including heating, cooling, lighting, receptacle loads, etc.

Using the regional (RegGridemissionfactors2007.pdf @ AE 481 Mech folder) or specific central power plant source grid associated emissions (CentralPlantemissionfactors2004.pdf, NYCAreaGeneratorsemissionfactors2007.xls @ AE 481 Mech folder) associated with delivered electric energy for your building location and the emissions

profiles associated with any on-site combustion system (boiler), determine the annual emissions footprint of the existing building lbm CO2/year, lbm NOx/year, lbm SOx/year, lbm particulates/year) of the building operation. You will need to do the same analysis for the operation of your redesign in order to quantify the emissions footprint enhancements of the redesigned facility.

Technical Report 3: Mechanical systems existing conditions evaluation

This report should provide a clear, concise summary of your building's Mechanical system, including design requirements, external influences on design, major hardware components, system configuration, control logic, and operating characteristics. In addition, the report should consider the merits of the system as a response to the requirements of the building program.

The specific organization of the report is left to your discretion, but it should be logical, concise and complete. Report content should include:

. Design objectives and requirements

. Energy sources and rates for the site (those that are used and those that could be used, including district heating and cooling)

. Site, cost (e.g., rebates, tax relief, etc.) and other factors that influenced design (if applicable)

. Outdoor and indoor design conditions

. Design ventilation requirements (designer, if available, and your estimate for entire building or representative systems from assignment 1)

. Design heating and cooling loads (designer, if available, and your estimate from assignment 2). If you have designer loads, compare with your estimates and discuss differences.

. Annual energy use (designer, if available, and your estimate from assignment 2)

. Schematic drawings of existing Mechanical systems (**drawn by you, <u>not</u> cut and paste from design documents**). See "FlowDiagrams.pdf" on the Y-drive for further guidance on how to develop effective flow diagrams.

. Tables(s) summarizing major equipment (edited, simplified lists, <u>not</u> copies of design documents) Major equipment items include boilers, chillers, cooling towers, air-handling units, pumps, etc. Schedules may be condensed for systems with numerous small pieces of equipment as in the case of a water loop heat pump system.

. Description of system operation on a conceptual level (plain English, <u>not</u> a verbatim repetition of the Sequence of Operation). <u>This discussion must make specific references to your schematic drawings</u>. For example, in describing the operation of a variable speed pump, you would identify the pressure sensor or flow meter controlling pump speed.

. Beakdown of the lost usable space associated with your mechanical system (mechanical equipment floor space and vertical mechanical shaft area)

. Operating history of system (if available). In particular, try to obtain annual energy utilization data – electric power (kWh) and fossil fuel (e.g. therms of natural gas or gallon of fuel oil). Meter data or utility bills for existing buildings are ideal, if such information can be obtained. If obtained, compare actual performance with your estimated values Mechanical system first cost, both total and per sq. ft. You are not expected to generate that number for this assignment. Rather, take it off of the bidding documents.

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. Assess your building's mechanical systems using the LEED rating system for new construction/major renovations. You can download a pdf version from the US Green Building Council (USGBC) website (http://www.usgbc.org/) or copy it from the AE Y-drive.

. Overall evaluation of system, including discussion of construction cost, operating cost, space requirements, maintainability, environmental control and indoor air quality issues. Results of previous assignments should be incorporated as necessary to address these issues. Note that a "critique" does not imply "criticism" in a pejorative sense. It is a critical evaluation, which can be positive, negative, or neutral. The primary goal of this assessment is to identify opportunities for your 482 mechanical project.

Keep in mind that this is assignment requires a report, not just a list. You are expected to write in clear technical prose, making appropriate use of tables and graphics to present the required information. Tables and figures should have numbers and titles/captions. You should reference them by number in your text. Citations for reference materials should be given in a reference list at the end of the report text.

AE 482 Mechanical project proposal

The proposal document must clearly explain the scope of your redesign project, provide justification for the proposed project based on the existing conditions of the facility, and indicate in sufficient detail the tools and methods you will use to accomplish the work. Thorough and detailed planning at this stage will help ensure a successful, high quality result.

Proposal requirements

. Description of all the alternatives considered.

. Description of the proposed redesign and the existing systems it replaces or modifies

. Justification of proposed work including, as applicable, impact on energy consumption, comfort, air quality, operating cost, construction cost, maintainability, etc. Educational value is a valid justification!

. Discussion of integration and coordination aspects of the proposed project. In particular, don't forget to consider the impact of the building envelope on Mechanical system performance.

. Preliminary research: provide annotated bibliography of technical papers, articles, and other reference materials you have examined that are relevant to the proposed work.

. Description of tools and methods that will be used to substantiate and ensure the rigor of your work. Discussion should convey an understanding of difficulties or limitations associated with their use for your project.

. Draft work plan for spring semester

Consultants

You will be assigned a Mechanical Systems faculty advisor who will grade all assignments, and for whom you will complete an AE 497 SRTE at the end of the semester. You are free to consult with any of the faculty as you develop your proposal for the Spring Semester (AE 482). Advisor assignments will usually be continued in AE 482.

Your advisor may establish a mandatory progress meeting schedule, and you are encouraged to schedule other appointments as necessary throughout the semester.