IPRO 302

CO_2 Mitigation: A Techno-Economic Assessment

Project Plan

Instructor: Don Chmielewski

Sponsor: Sargent & Lundy

Team:

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1.0 Objectives

- Perform an in-depth analysis of all aspects of implementing the selected CO_2 mitigation technology from the sponsor by researching methods of sequestration and designing CO_2 removal equipment with the assistance of MATLAB models of the power plant and Hysys models of the CO_2 removal equipment.

- Provide a thorough economic analysis in order to assess the impact on power generation cost. This will include determination of capital costs for the operation and construction of CO_2 removal and sequestering equipment to the existing power plant.

2.0 Background

A. Sponsor: The sponsor for IPRO 302 is Sargent & Lundy. Founded in 1891, this company provides comprehensive consulting services for solar, fossil, and nuclear-electric power generation within the nation and worldwide. Their experienced and dedicated staff can handle tasks of any size and can deliver cost-effective results.

B. Problem: Global warming due to the emissions of CO_2 by human activity has an increasing exposure to the public eye. Governments are planning on implementing CO_2 emissions regulations to quell this problem. Power plants will have to conform to these regulations in the future. Therefore, power generation companies are especially interested in minimizing costs required for efficient carbon dioxide separation and storage. Both governmental bodies and private institutions are currently working to determine the most cost effective way to implement CO_2 mitigation. Sargent & Lundy is currently working with the utility industry to formulate optimal CO_2 mitigation strategies. They are working with our IPRO team to develop a greater understanding of cost minimization for various CO_2 emissions requirements.

C. Technology/Science: The main focus of this IPRO is to research solutions to modify coal-based power plants in order to reduce CO_2 emissions. The majority of this project is design-oriented and focuses on developing advanced computer models of a conventional, pulverized, coal-fired boiler and packed column ammonia based CO_2 absorber and stripper. In order to optimize costs associated with CO_2 separation and ultimate storage, the project will also be concerned with current and future environmental regulations and sequestration feasibility.

D. Prior Work: The previous semester project was research-based and focused on finding information on the following technologies: oxy-combustion pulverized coal-fired boilers, conventional pulverized coal-fired boilers, and Integrated Gasification Combined Cycles (IGCC). Current and future environmental regulations and sequestration techniques were also studied. For each of the listed technologies, case studies were examined to determine component vendors with the most favorable characteristics (cost, space, maturity).

E. Issues: Based on previous research of the effect that CO_2 emissions have on the environment, environmental concerns are obvious. One of the largest challenges our research faces is finding appropriate storage or use for the excess CO_2 that could be potentially harmful to the environment. Another challenge that we face is determining how to upgrade not only new, but existing power plants so that they can effectively provide efficient and clean energy in the future.

F. Business/Societal Costs: There are two prominent issues regarding cost: the expense of modifying existing power plants and the problem of how to safely and efficiently store the removed CO_2 in a manner that is compliant with current and future regulations. Obviously implementing a solution to reduce CO_2 emissions of every plant in America will be expensive. These additional costs may be passed on to consumers. Minimal costs will have to be maintained in order to support a robust energy industry.

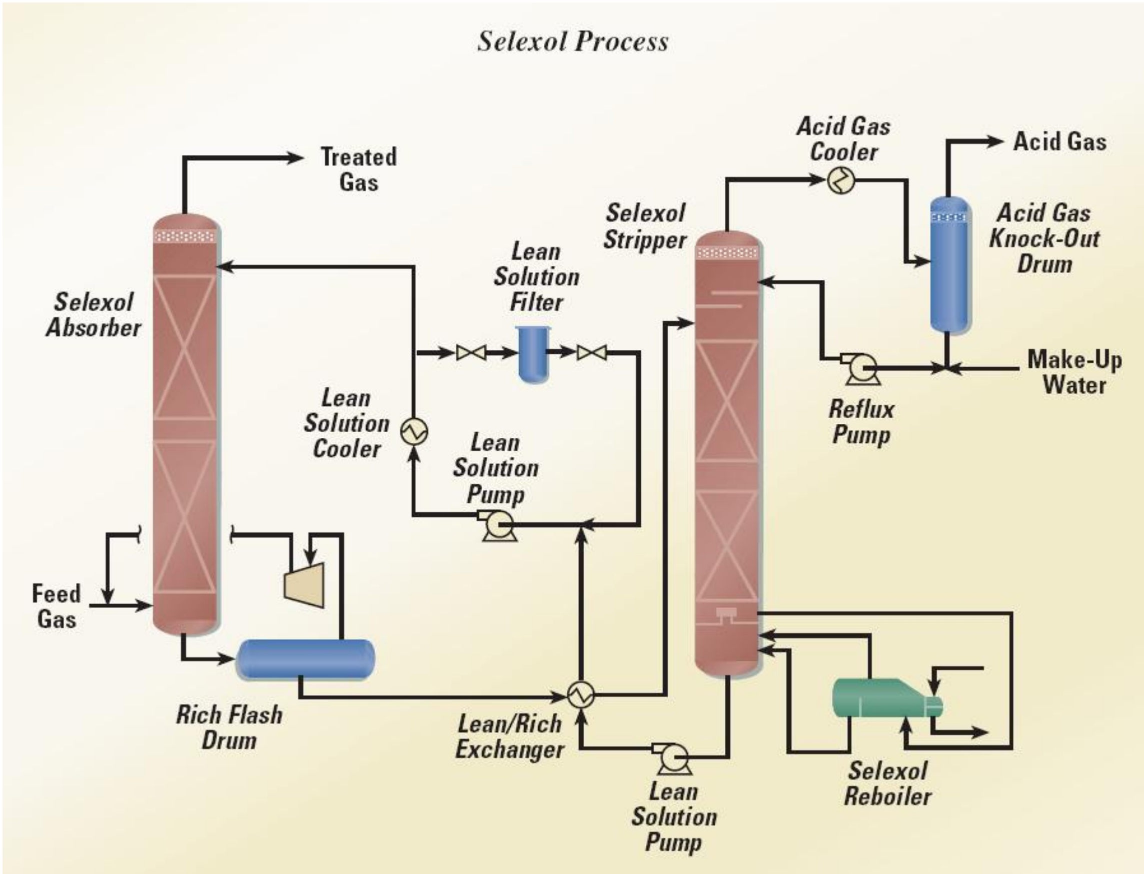
G. Implementation: Following the research conducted by the Fall 2007 project, this project will complete an in-depth technical and economic analysis of all aspects of implementing the chosen technology on a conventional pulverized coal-fired boiler. The method selected by the sponsor will involve the chemical absorption of CO_2 into an Ammonia solution followed by a separate stripping process to remove the separated CO_2.

H. Research: There are various methods currently in use for CO_2 mitigation in industries that emit a substantial amount of the gas. Most of these methods can generally be classified into chemical mitigation and biological mitigation.

Chemical mitigation involves the use of solvents to dissolve and strip CO_2 – namely ammonia, Rectisol, Selexol, Sulfinol and several amines.

<u>Rectisol</u>
This method, currently licensed by the German company Lurgi AG, is an acid gas removal that separates acidic gases such as hydrogen sulfide and CO_2 from the gas streams. The solvent used is refrigerated methanol (at approximately -40°F) which dissolves the acid gases and is then steam stripped to release and recover the acid gases. This process is relatively expensive, yet is used to purify 75% of the world's synthesis gas produced from coal, heavy oil and wastes.

<u>Selexol</u>
The method follows a process similar to Rectisol, but uses different solvents in the form of dimethyl ethers of polyethylene glycol. Because Selexol uses a physical solvent rather than a chemical one, it is not subject to degradation over time, and disposal is therefore not an issue to be concerned with. Currently, the Selexol process is used in more than fifty units worldwide, and has been employed for over thirty years.



Sulfinol

The Sulfinol process is a regenerable amine process used for the bulk removal of CO_2 from reactor streams. It employs a mixture of two or more alkanoamines with water and sulpholane which constitutes its solvent. The process also performs the removal of hydrogen sulfides, mercaptans and other organic sulfides. The process was originally developed by the Shell Oil Company in 1964 and is still used by the company today.

Amines

Several alkanolamines are generally used to treat gases in refineries, petrochemical and natural gas processing plants among others. The common amines used are: monoethanolamine (MEA), diethanolamine (DEA) and methyl diethanolamine (MDEA). These alkanoamines are used to produce CO_2-reactive salts for sequestration purposes.

Biological mitigation refers to the cultivation of organisms that naturally capture atmospheric CO_2. This method of mitigation is relatively unpopular for it generally requires a lot of time. However, studies continue to be performed for it represents a more naturalistic solution and a better long-term solution.

Photosynthetic microbes

After previous government-funded researches in Japan and US met with failures, a privately-funded program managed to successfully cultivate photosynthetic microbes in a 2-ha commercial scale. The production system couples photobioreactors with open ponds in a two-stage process. It has been reported that the system has operated continuously for several years to produce *Haematococcus pluvialis*. The study exhibited results that surpassed initial expectations in terms of oil and energy production. This would enable us to eliminate a substantial fraction of the yearly production of CO_2 through fossil fuel emissions.

Oceanic primary production by adding iron

Primary production refers to the creation of organic compounds from CO_2 through photosynthesis or chemosynthesis. Ocean phytoplankton are responsible for approximately half the global biospheric net primary production. Long-term changes in ocean primary production would have adverse effects on the global carbon cycle. The reductions in primary production corresponds to increases in oceanic temperatures and reductions in atmospheric deposition of iron into the oceans. The iron comes from the desert dust that is carried by the winds to the oceans as eolian dust. However, certain oceanic regions are relatively distant from any desert (such as the Southern and North Pacific Oceans) and hence lack primary production. Thus, the artificial deposition of iron onto such regions would increase primary production.

Oxy-Combustion

One of the difficulties associated with separation in traditional pulverized coal-fired power plants, is that there is a large volume of nitrogen in the flue gas stream. This is because the combustion is performed in the boiler using standard atmospheric gas, mainly composed of nitrogen. Large quantities of nitrogen gas in the flue gas stream have the effect of diluting the CO_2 gas content, so that in order to separate a given amount of CO_2, a large total volume of gas must pass through the CO_2 separation unit. By replacing most of this nitrogen with additional oxygen in the boiler, the flue gas will have a much higher concentration of CO_2, which can then be more easily separated. Unfortunately, the addition of the oxygen separation stage before the boiler incurs additional energy penalties to the power generating facility.

IGCC (Integrated Gasification Combined Cycle)

IGCC power plants differ from standard pulverized coal-fired (PC) plants, providing much cleaner energy with reduced emissions. Within the gasification stage of the plant, synthesis gas is produced by breaking down coal with the aid of heat, pressure, pure Oxygen and water. Thermal reaction with excess fuel releases heat which is used to drive water into steam power as in the pulverized coal-fired process. Synthesis gas created in the thermal reaction is then used to power a gas-turbine-generator set providing additional power.

Most of the particulates in an IGCC process can be captured after the first boiler stage in a series of smaller pollution control stages, in comparison with similar yielding pollution control stages of a pulverized coal-fired process. Clean synthesis gas is the product of these stages which in turn lowers CO_2 emissions. It is widely accepted that the incremental cost of adding CO_2 separation and capture technology to existing IGCC plants is lower than the cost of adding CO_2 mitigation technology to existing PC plants. Additionally, part of the gas stream can be used in a Fischer-Tropsch process to produce additional synthetic chemicals, the sale of which can provide value-added profit potential.

Unfortunately, IGCC plants fitted with such CO_2 mitigation technologies are not cheap. Capital costs increase by approximately a third with the implementation of this technology in comparison to IGCC plants without CO_2 capture technology. Furthermore, operation costs of CO_2-capturing IGCC plants are significantly higher. Some predictions suggest that were they to become operational in the United States, IGCC plant owners would pass on the additional costs associated with CO_2 capture to the consumers. This might have the effect of further contributing to economic stagnation. The disagreement between lawmakers and sponsors may have served as the basis for the U.S Department of Energy's recent decision to pull funding for its 'FutureGen' project, where it supported the building and testing of several IGCC plants over the next 10 years.

3.0 Methodology

A. Future regulations may impose CO_2 emission and removal requirements. Sargent & Lundy is interested in finding economical solutions to retrofit existing power plants with modern and effective CO_2 removal systems to meet these requirements.

B. Based on a preliminary understanding of the tasks required to complete the project, we divided the team members into two main sub-teams, namely the *Flue Crew* and the *Steam Team*. The Flue Crew will be primarily responsible for designing the CO_2 removal unit and would be comprised of the senior Chemical Engineering students. Composed of Mechanical, Aerospace and Electrical Engineering students, the Steam Team is concerned with the power generation section of the plant and providing energy to the additional pollution-control measures. Due to additional resources provided by CHE296 students, we were then able to assign additional manpower to each sub-team while also allowing some to work directly with the project leader. After dividing the teams in this manner to make effective use of educational specializations, the necessary stream of requirements became more apparent.

First, the steam team will estimate the composition of flue gas as well as the temperature and flow rate in order to develop an understanding and model of the chemical and thermal processes involved in each stage of the cycle. Using this base model to determine the heat and temperature requirements, the Flue Crew will then create advanced computer models (Hysys) to determine energy and steam requirements for six cases of CO_2 removal. These energy requirements will then be passed back to the Steam Team in order to adjust their base model to fit redistribution of steam to meet these requirements. Iterations of this process will be repeated as necessary. The model will also help in determining the change in net power production of the power plant. While the Flue Crew models the CO_2 removal process, they will also perform a detailed economic analysis of the costs associated with operation of the new system.

In order to meet all deliverable deadlines in a timely manner, all team members were again subdivided into deliverable sub-teams: Ethics, Reports, Presentation, Exhibits and Website. By taking into account each team member's personal preferences as well as their unique skills, an even distribution of manpower was achieved.

C. With an expertise in the field of power generation, Sargent & Lundy has already developed a report on the same subject of our project, but independently. They will examine the results of this project to compare them with their own solutions. Our lack of knowledge in their process will hopefully reinforce their conclusions. In this fashion, Sargent & Lundy will be able to make an unbiased and objective comparison of the two reports to ensure that they have examined all considerations.

D. Each sub-team will upload their completed models and the conclusions generated to iGroups to promote sharing of information and allow additional input from members not available during regularly scheduled meetings.

E. Due to the fact that we will not be performing the tests, we will have no documentation on the testing of our product.

F. While the actual content of the reports will be assigned on an individual and group basis, the report itself will be assembled and edited by the reports team to be presented to the group for refinements before being ultimately submitted on iKnow.

4.0 Expected Results

A. We expect our culminated efforts to result in six designs for CO_2 removal equipment which could be added to the coal power plant in Council Bluffs, Iowa.

B. This is to be performed by developing and using a Matlab model which will simulate the coal power plant process and a HySys model which will simulate the CO_2 removal equipment. Six designs will be developed-namely at 35°F and 100°F at 25%, 50%, and 90% CO_2 removal from the flue gas. The physical demands and government regulations in Iowa involving the sequestration of CO_2 will be explored, and the most cost-efficient method of sequestration will be determined so that the removed CO_2 can be readily disposed. Economic analysis will be performed on each simulated case to determine which operating temperature will be the most cost-effective and how much CO_2 removal would add to the cost of operating the coal power plant for each case. We expect that the higher temperature process will be the most cost-effective option for each CO_2 removal percentage and that the cost per pound of CO_2 removed from the flue gas will increase as the percentage removal increases due to increased equipment and energy costs. We are not performing any experiments to further test the design due to the large costs associated with building the equipment.

C. The potential products resulting from the research and simulation involved with this project are CO_2 removal equipment that can be added to existing coal power plants and methods to sequester the removed gas to accommodate future CO_2 emission regulations. The CO_2 is removed from the flue gas by sending the flue gas into an absorption tower where an ammonia and water solution dissolves the CO_2. The ammonia, water, and CO_2 solution will then be sent to a stripping tower where the CO_2 will be recovered in its gaseous form and piped to a site where it can be sequestered or stored in tanks which will be shipped to a sequestration site.

D. The steam team is responsible for determining the amount of coal used by the power plant, the amount of energy produced by the power plant, and the composition of the flue gas which will undergo CO_2 removal. These outputs are given to the flue crew so that they can design the CO_2 removal process. The flue crew is responsible for modeling and designing the CO_2 equipment and performing an economic analysis of the proposed removal and sequestration processes. These two outputs and the heat required to remove the CO_2 from the flue gas are calculated by the flue crew. The teams iterate with these outputs until the final output from the two collective teams produce a good design and accurate economic analysis for the implementation of CO_2 removal technology to the power plant. Three teams of sophomore chemical engineering students research CO_2 sequestering regulations in Iowa, locations where the CO_2 can be disposed, and technologies involved in sequestration. The collective output of the sophomore chemical engineering teams is a method to sequester CO_2 which is cost-effective, technologically feasible and is in accordance with governmental regulations.

E. Based on the results, we would produce a final report for the sponsor with the conclusions of our study.

F. We expect to address Sargent & Lundy's concerns about planning for future CO_2 emissions regulations by supplying them with designs and economic analysis for CO_2 removal processes which could be implemented in the coal power plant they are working on in Iowa.

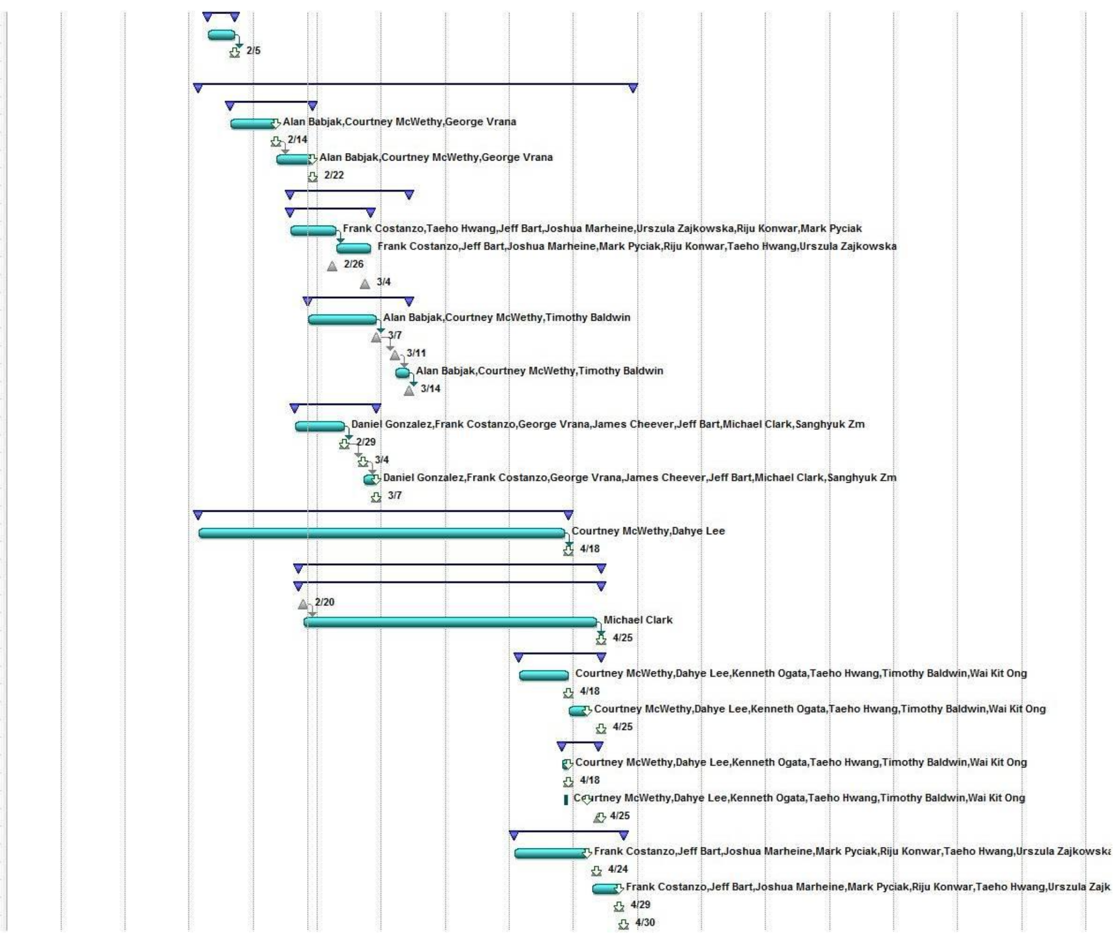
G. While Sargent & Lundy has researched this problem on their own, our results will fit into the solution framework by either confirming that their solution is the right one or giving them an improved solution.

5.0. Project Budget

ITEM	QTY	PRICE	PURPOSE
DVDs	14	$ 10.19	Documentary on Global Warming for general overview of problem.
6ft VGA cable	1	$ 10.71	Used to connect laptop to projector for all classroom sessions.
Printing Costs	1	$ 150.00	IPRO Day Poster and Abstract printing costs.
Team-Building	1	$ 198.10	Team Building weekly incentives and end-of-project celebratory expenses.
Total		**$ 369.00**	

6. Schedule of Tasks and Milestone Events

Project Organization	**4 days?**	**Thu 1/31/08**	**Tue 2/5/08**	
Discuss Team Structure	4 days?	Thu 1/31/08	Tue 2/5/08	
Determine Team Structure	1 day?	Tue 2/5/08	Tue 2/5/08	2
Deliverables	**70 days?**	**Tue 1/29/08**	**Fri 5/2/08**	
Project Plan	**14 days?**	**Tue 2/5/08**	**Fri 2/22/08**	
Work on Project Plan Rough Draft	8 days?	Tue 2/5/08	Thu 2/14/08	
Get Input From Team about Project Plan	1 day?	Thu 2/14/08	Thu 2/14/08	
Make Corrections to Project Plan	6 days?	Fri 2/15/08	Fri 2/22/08	8
Project Plan Due	1 day?	Fri 2/22/08	Fri 2/22/08	
Midterm Deliverables	**20 days?**	**Mon 2/18/08**	**Fri 3/14/08**	
Midterm Progress Report Presentation	**.71 days?**	**Mon 2/18/08**	**Thu 3/6/08**	
Work on Midterm Progress Presention	8 days?	Mon 2/18/08	Wed 2/27/08	
Do Corrections on Midterm Progress Presentation	5.71 days?	Thu 2/28/08	Thu 3/6/08	13
Midterm Progress Presentation Practice	1.14 days?	Tue 2/26/08	Wed 2/27/08	
Midterm Progress Report Presentation Due Date	1.14 days?	Tue 3/4/08	Wed 3/5/08	
Midterm Progress Report Paper	**16 days?**	**Fri 2/22/08**	**Fri 3/14/08**	
Work on Midterm Progress Report Paper Rough Draft	11 days?	Fri 2/22/08	Fri 3/7/08	
Post Midterm Progress Report for Input	1 day?	Fri 3/7/08	Fri 3/7/08	18
Get input from team for corrections to the paper	1 day?	Tue 3/11/08	Tue 3/11/08	19
Do Corrections on Midterm Progress Report Paper	3 days?	Wed 3/12/08	Fri 3/14/08	20
Turn in Midterm Progress Report	1 day?	Fri 3/14/08	Fri 3/14/08	21
Ethics Paper	**14 days?**	**Tue 2/19/08**	**Fri 3/7/08**	
Work on Ethics Presentation Rough Draft	9 days?	Tue 2/19/08	Fri 2/29/08	
Post Ethics Paper Rough Draft for Input	1 day?	Fri 2/29/08	Fri 2/29/08	24
Get input from team for corrections on paper	1 day?	Tue 3/4/08	Tue 3/4/08	25
Make corrections to ethics paper	3 days?	Wed 3/5/08	Fri 3/7/08	26
Turn in Ethics Paper	1 day?	Fri 3/7/08	Fri 3/7/08	
Meeting Minutes	**59 days?**	**Tue 1/29/08**	**Fri 4/18/08**	
Take meeting minutes/post on igroups	58 days?	Tue 1/29/08	Thu 4/17/08	
Meeting Minutes Due	1 day?	Fri 4/18/08	Fri 4/18/08	30
IPRO Day Deliverables	**49 days?**	**Wed 2/20/08**	**Fri 4/25/08**	
Web Site	**49 days?**	**Wed 2/20/08**	**Fri 4/25/08**	
Put up initial web site design	1 day?	Wed 2/20/08	Wed 2/20/08	
Periodically update website	47 days?	Thu 2/21/08	Thu 4/24/08	34
Final web site due	1 day?	Fri 4/25/08	Fri 4/25/08	35
Exhibit/Poster	**15 days?**	**Tue 4/8/08**	**Fri 4/25/08**	
Design Exhibit/Poster rough draft	9 days?	Tue 4/8/08	Fri 4/18/08	
Post design for input	1 day?	Fri 4/18/08	Fri 4/18/08	
Get input from team for corrections on paper	3 days?	Sat 4/19/08	Tue 4/22/08	
Exhibit/Poster Due	1 day?	Fri 4/25/08	Fri 4/25/08	
Abstract/Brochure	**.67 days?**	**Thu 4/17/08**	**Fri 4/25/08**	
Design Abstract/Brochure	1.5 days?	Thu 4/17/08	Fri 4/18/08	
Post design for input	).17 days?	Fri 4/18/08	Fri 4/18/08	
Get input from team for corrections on paper	0.5 days?	Fri 4/18/08	Fri 4/18/08	
Abstract/Brochure Due	).17 days?	Fri 4/25/08	Fri 4/25/08	
Final Presentation	**19 days?**	**Mon 4/7/08**	**Wed 4/30/08**	
Make final presentation rough draft	13 days?	Mon 4/7/08	Tue 4/22/08	
Practice presentation	1 day?	Thu 4/24/08	Thu 4/24/08	
Make corrections to presentation	4 days?	Thu 4/24/08	Tue 4/29/08	
Practice presentation 2	1 day?	Tue 4/29/08	Tue 4/29/08	
Give presentation	1 day?	Wed 4/30/08	Wed 4/30/08	



	Task Name	Duration	Start	Finish	Predecessors
	Final Report w/ Table of Contents	**22 days?**	**Thu 4/3/08**	**Thu 5/1/08**	
	Make final report rough draft	4.13 days?	Thu 4/3/08	Wed 4/9/08	
	Post final report rough draft for input	1 day?	Fri 4/18/08	Fri 4/18/08	54
	Get input from team for corrections on paper	1.88 days?	Wed 4/23/08	Thu 4/24/08	55
	Make corrections on final report	1.88 days?	Fri 4/25/08	Mon 4/28/08	56
	Final report due	0.38 days?	Thu 5/1/08	Thu 5/1/08	57
	IPRO CD	**36 days?**	**Mon 3/17/08**	**Fri 5/2/08**	
	Submit IPRO CD	1 day?	Fri 5/2/08	Fri 5/2/08	
	Spring Break!	5 days?	Mon 3/17/08	Fri 3/21/08	
	Design	**39 days?**	**Tue 2/19/08**	**Fri 4/11/08**	
	Steam Team	**34 days?**	**Tue 2/19/08**	**Fri 4/4/08**	
	Present overview of design to IPRO group	1 day?	Tue 2/19/08	Tue 2/19/08	
	Make base model of first case	16 days?	Tue 2/19/08	Tue 3/11/08	
	Model Integration of the First Case	4 days?	Wed 3/12/08	Mon 3/17/08	67
	Integrate models for the last 5 cases	9 days?	Tue 3/25/08	Fri 4/4/08	68
	Flue Crew	**39 days?**	**Tue 2/19/08**	**Fri 4/11/08**	
	Present overview of design to IPRO group	1 day?	Tue 2/19/08	Tue 2/19/08	
	Make base model for first case	16 days?	Tue 2/19/08	Tue 3/11/08	
	Model Integration of the First Case	5 days?	Tue 3/11/08	Mon 3/17/08	73
	Integrate models for the last 5 cases	9 days?	Tue 3/25/08	Fri 4/4/08	74
	Economic analysis of first case	6 days?	Tue 3/25/08	Tue 4/1/08	74
	Economic analysis of last 5 cases	8 days?	Wed 4/2/08	Fri 4/11/08	76
	Research teams	**44 days?**	**Tue 2/5/08**	**Fri 4/4/08**	
	Research background for project plan	9.17 days?	Tue 2/5/08	Mon 2/18/08	
	Research for flue crew team	33 days?	Wed 2/20/08	Fri 4/4/08	80
	Research for steam team	33 days?	Wed 2/20/08	Fri 4/4/08	80
	Research for team leader	33 days?	Wed 2/20/08	Fri 4/4/08	80

7.0 Individual Team Member Assignments

George Vrana – George is the team leader for IPRO 302, and will also be working on the reports team for this project. Originally from Canada, George is a member of the Royal Conservatory of Music in Toronto. He has an extensive musical background and has taken lessons in music theory, piano, voice and classical guitar. In addition, he won awards in various musical festivals for both solo and ensemble performance throughout Ontario. He gained valuable experience with CAD, as well as project management and public speaking skills, while working for a major manufacturing company of automated packaging machinery. His other hobbies include competitive tennis, water-skiing, alpine-skiing and snowmobiling.

Alan Babjak- Alan is a senior in the Chemical and Biological Engineering department. He lived in Illinois all of my life. His family is large, but they are dispersed throughout the country. After graduating high school, he worked full time for some years while completing an Associate's in Science at Moraine Valley Community College. Over his work and school experience there, he decided he wanted to spend his work life working on technological problems which led him to pursue a Chemical Engineering degree. When time is available, he likes to be involved in archery, camping, hunting, fishing, and hiking. He is working on the design of CO_2 removal technology and reports.

Dahye Lee –Dahye is a fourth year student in the Chemical and Biological Engineering department. She is from South Korea, and her academic interest is in chemical biology. Her experience includes research in the area of olefin refinery design and optimization. Her skills consist of document organization and data retrieval. She enjoys tennis, jogging, and exquisite cuisine. Dahye considers patience one of her strengths. As a member of the Flue Crew, she is currently working in the design of CO_2 removal technology. She is also on the exhibit team, and is taking the meeting minutes.

Francis Costanzo- Francis is a senior in the Chemical and Biological Engineering department. He was born and raised in Chicago. He graduated from the CPS system in both grammar school and high school. He attended grammar school at Hawthorne Scholastic Academy and high school at Northside College Prep. He was a former member of Pi Kappa Phi fraternity here on the IIT campus and was once active in campus life, but he has since moved on and is very much looking forward to beginning employment with Sargent and Lundy after graduation. His hobbies include hanging out with friends, water polo, sports, music, breweriana, and movies. He still very much enjoys exercising and is still an avid swimmer and continues to play water polo competitively for Chicago Riptide out of Gill Park on the north side of Chicago. He is also a B.S.A. Eagle Scout and is very proud of my many accomplishments in the scouting community. He is set to graduate from IIT in May, 2008 with a B.S. in Chemical Engineering. He is working in the design of carbon dioxide removal technology and is on the presentation team.

Courtney McWethy- Courtney is a fourth year student of Aerospace Engineering and is also working on taking meeting minutes and designing of the coal fired plant. Although her work in this field is restricted to classes only, MMAE 320, thermodynamics, did allow her some knowledge of boilers. MMAE 452, aerospace propulsion, also detailed turbines and compressors, which may be of use in this IPRO. Courtney's other activities on campus include being the president, social internal chair, and public relations chair for Zeta Pi Omega Sorority. When she is not performing tasks for school or sorority, she likes to sew, read, and chat online. Courtney is also on the reports team.

Daniel Gonzalez- Daniel is a third year Electrical Engineer who was born in the state of Michoacán, Mexico and migrated to the United States at the age of 9. While he has no actual experience outside from classes, he is taking MMAE 320, Thermodynamics, and ECE 319, Fundamental of Power Engineering where he will acquire the knowledge to understand more in depth the process inside a power plant. He also has good writing skills and is bilingual, speaking and writing in both Spanish and English. Daniel attended Thomas Kelly High school where he was enrolled in the IB (International Baccalaureate) program and received the IB diploma. Once there he participated in city and state band and solo competitions, for which he received Division 1 ratings, and also became a member of the TriM (Modern Music Masters) honor society. His hobbies include playing clarinet, guitar, soccer, baseball, video games, reading, and dancing. Daniel is working in the design of the coal fired plant team. He is also on the ethics team.

James Cheever- James is a second year Chemical Engineering student at Illinois Institute of Technology. He grew up in Midlothian, Illinois and currently lives in Country Club Hills, Illinois. He has basic accounting knowledge from working part time at an office and also has some skill with Matlab, Maple, and C++. He is interested in working in alternative fuels after graduation. In his spare time, he likes to read, play sports, mainly tennis and football, and play chess.

Jennifer Guilfoyle-Jennifer is a second year Chemical Engineering student pursuing her second bachelor's degree. She first attended Elmhurst College and graduated with a Bachelor of Music in Music Business. She enjoys singing, reading and making arts and crafts with her spare time. Jennifer worked as the Webmaster and is currently the Regional Conference Coordinator for the student AIChE IIT chapter. She is working with the team leader to help organize and do research for this IPRO.

Katherine Lazicki- Katherine is a second year chemical engineering student with an interest in environmental engineering. She is from Park Ridge, IL, but currently lives on campus. Along with the scientific knowledge gained from a year and a half of academics at IIT, she knows basic accounting and can write and edit papers. She works part-time for the Chemical and Biological Department of Engineering. Through this department, she contributed to a project on the feasibility of the installation of solar panels on Chicago Public School roofs. In her spare time, she enjoys reading, sketching, and editing her friends' literary works.

Kenneth Ogata- Kenneth is currently second year in chemical engineer major. He grew up in Hawaii. He enjoys playing soccer, going to the beach, going hiking and other outdoor activities. He is planning to minor in biochemistry. He is currently involved in varsity soccer.

Sithambara Kuhan- Kuhan is a Chemical Engineering major, currently in his third year. He originally transferred as an international student from Malaysia, and has been at IIT for a year. Kuhan was actively involced in extra-curricular activities back in high school. He was also the chairperson of the English Language Society in his previous college in Malaysia, and is currently a member of the AIChE student chapter at IIT. His interests range through a variety of sports and games, including soccer, ping-pong and Scrabble. He also has a passion for writing. He is currently a member of the Flue Crew for this IPRO, and is also involved in preparing reports for the group.

Taeho Hwang –Taeho is a fifth year Chemical Engineering student at Illinois Institute of Technology. He is from South Korea, and majored environmental engineering in Ajou University in Korea. He is working on undergraduate research with Prof, Ramani about Fuel Cells. After graduation, he is willing to pursue graduate studies and has already received some doctoral admissions. For a summer internship, he has worked in a wastewater treatment plant. He has completed two years of military service as a sergeant. For this project, Taeho is on the Flue Crew working to design the carbon dioxide removal technology. He is also on the exhibit team.

Wai Kit Ong – Wai Kit is a third year Chemical Engineering student, with a minor in Business. He is a transfer student from Malaysia and has been in the United States for a year. Before transferring to the United States, he was a Chemistry tutor for his college. In the past year, he had been a Check-in Program volunteer at the International Center and a Student Honor Marshal for the Fall 2007 Commencement ceremony. He was also initiated as a fellow Tau Beta Pi member last year. This year, he will be taking part in the AIChE Chem-E Car Competition. During his free time, he enjoys playing table tennis and watching movies. He has basic knowledge in C++ and Matlab. Finally, he is part of the Flue Crew.

Jeff Bart- Jeff Bart is a third year mechanical/materials engineering student. His experience within this field is limited to material within his education at the Illinois Institute of Technology. His strengths include problem solving and analysis. Jeff's interests include paintball, archery, shooting, hockey, fishing and snowmobiling. He is on the "Steam Team" of IPRO 302 and is also participating in the ethics and presentations portions of the IPRO deliverables.

Riju Konwar-Riju Konwar is a fourth year undergraduate pursuing a triple major in Chemical, Mechanical and Bio-medical Engineering. His interest lies in playing basketball, and swimming. On the lazier side, he is interested in playing chess while sitting idle in the park with his friends. Traveling is another of his passions. He has been as far as the foothills of the Himalayas to the continent of Australia. His goal in life is to go to Medical School and eventually do research in Artificial Hearts. He is working on the Steam Team to help in design of the plant.

Michael A. Schillaci- Michael is a Chemical engineering student in his fourth year. He is a transfer student from South Suburban College. He currently lives in the Chicagoland area. He works as a bartender and on a cleanup crew. He works 5-6 days a week. He has lived around the country while in the military and prior to that, he lived on the eastside of Chicago. He has traveled and lived all over the country. He also has traveled to several different countries while he was in the U.S. Navy. He has six years of training, technical, and administrative experience in the U.S. Navy as a Nuclear Engineering Laboratory Technician and Nuclear Machinist Mate. He analyzed and maintained chemistry in nuclear, steam, and potable water system on board an aircraft carrier. He is currently working on the design of carbon dioxide removal technology.

Farouk Yaker-*Farouk Yaker* is a third year transfer student from Wilbur Wright college in Chicago, pursuing a bachelor degree in chemical engineering with a minor in E3 (environment, economy, and energy) at the Illinois institute of technology, and now doing a research on chemical and electrochemical characterization of novel electrode materials for batteries and fuel cells. He’s also interested in joining a graduate program in gas/petroleum engineering after graduation. Born and raised in Algeria, he’s fluent in French, Arabic and some basic Spanish; he moved and traveled a lot in and outside the states before attending the city college. He’s looking forward to the realization of the of CO_2 mitigation process plant in a real life application, by contributing to this project with his fellow members of the flue crew in the calculation and the simulation part of this process.

Timothy Baldwin- Timothy is a third year electrical engineering student. He grew up in Glen Ellyn, IL and currently resides in Humboldt Park in Chicago. He has studied at Tulane University in New Orleans and Loyola University Chicago. This is his second year at IIT. His outside interests include playing bass, listening to music and skateboarding. He is currently working as a bowling machine mechanic. His skills include mathematics, writing, and problem solving. Timothy is on the steam team and will also be working on the ethics team to help develop the code of ethics.

B. The team leader, George Vrana will coordinate and review subteam, and individual team member task activities.

C. Based on the tasks required to complete this IPRO, the group was broken into two main subteams, namely the “Flue Crew” and, “Steam Team”.

In order to encourage cooperation among team members with different backgrounds, all members were simultaneously assigned to specific deliverable subgroups to complete deliverables. Care was taken to ensure that each deliverable subgroup (presentations, reports, exhibit, and ethics) was comprised of a mix of students from different subteams and different technical backgrounds.

D. Main Sub Team Leaders:

Steam Team – none

Flue Crew - none

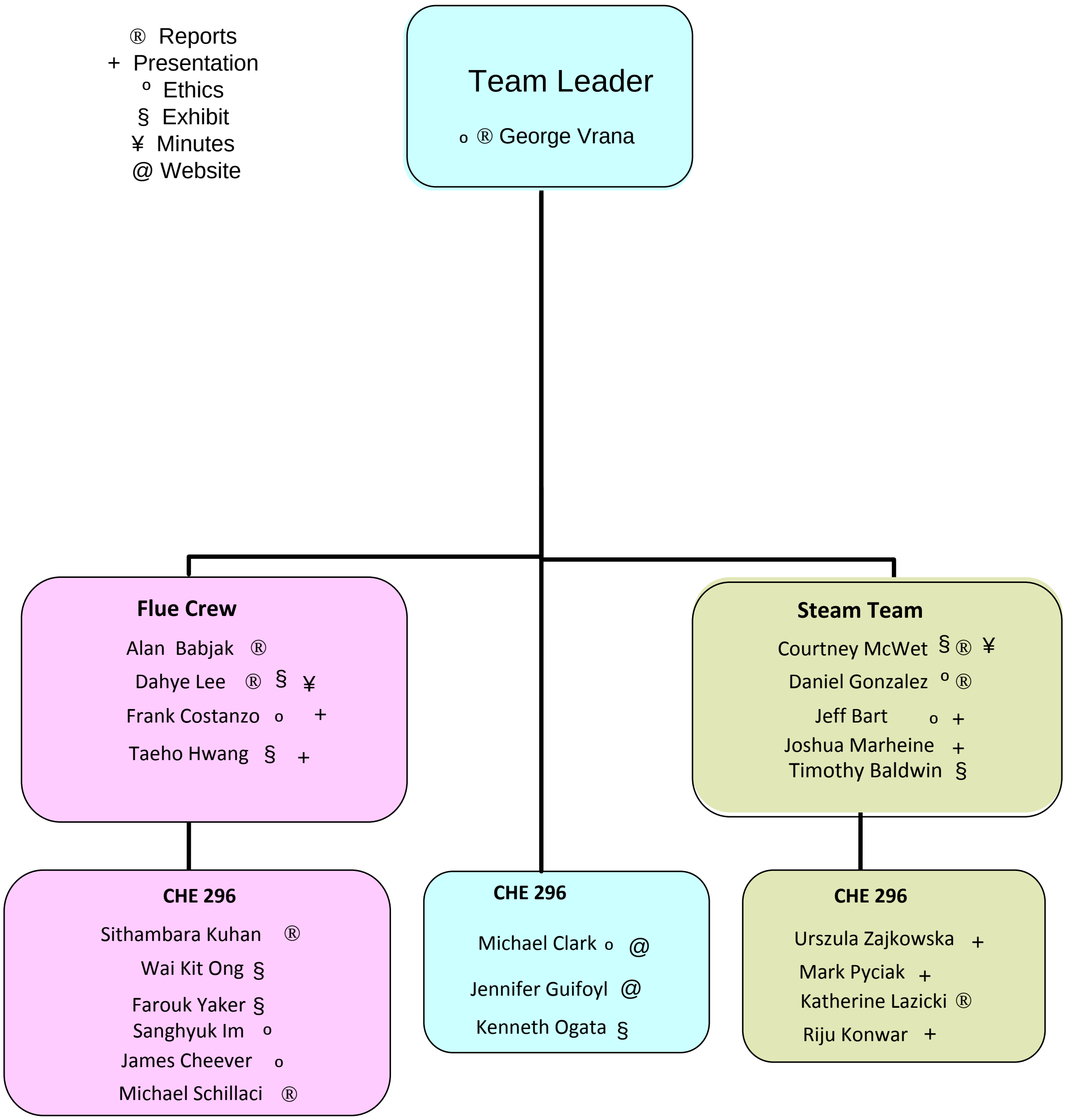
Deliverable subgroup leaders: none

E. The **"**Flue Crew" will be responsible for creating a model of CO_2 removal technology processes using Hysys™, and determining optimal stripper configuration for given removal requirement of CO_2. This will also include a detailed economic analysis of capital costs and operational costs associated with each scenario modeled. The "Steam Team" will be responsible for designing and modeling the power block portion of the pulverized coal-fired power plant, using computer software such as Matlab. Since the amount of carbon dioxide removed in the absorber/stripper is a function of steam, both main teams will need to communicate with each other on a regular basis to accomplish their main goals.

Deliverable subgroups will be broken down as follows:

- Presentation Team – Responsible for midterm presentation and final presentation, and the.
- Reports Team – Compiling all research, models and data to complete the project plan, midterm report, and final report.
- Ethics Team – Attended the code of ethics seminar and is responsible for developing the code of ethics.
- Exhibit Team – Responsible for all exhibit material, including final poster, abstract, and any physically displayed models for the IPRO Day exhibit.
- Website Team – Build and post final website for the entire project.

F. Sub Team Member Roles:



G. The sub teams function independently: the sub team leadership duties are shared among members. Everyone will be finding information and presenting it to the class. The team leader's role is to make sure that everything is being completed in a timely fashion.

8.0 Designation of Roles

A. Assign Meeting Roles
  - Minute Taker: Dahye Lee and Courtney McWethy
  - Agenda Maker: George Vrana
  - Time Keeper: George Vrana

B. Assign Status Roles
  - Weekly Timesheet Collector/Summarizer: Alan Babjak
  - Master Schedule Maker: George Vrana
  - iGroups: Jennifer Guilfoyle