Project Plan

IPRO 302
Impacts of Sulfur Capture Technology in Coal Power Plants

Fall 2009

I. TEAM CHARTER

1. TEAM INFORMATION

A. Team Roster

Chmielewski, Don	chmielewski@iit.edu
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Worthon, Terrika	tworthon@iit.edu

B. Team Member Profiles

Abraham Contreras - Abe is in his last semester at IIT, soon to receive a professional bachelor's in architecture. He plans to gain a better understanding of other fields and to work with people in other disciplines to solve a problem. He expects that this IPRO will involve extensive research and data analysis.

Justin Dickman - Justin Dickman is a fourth year Aerospace and Mechanical Engineering student. He possesses good leadership and communication skills. He hopes to gain some knowledge of how sulfur is captured from coal processed by power plants and its impacts on the environment. He hopes to also gain a perspective into how a group project works in the engineering industry.

Gregory Enadeghe - Gregory Enadeghe is a 4th year chemical engineering student with a strong interest in a business minor. He plans to gain an advanced knowledge of chemical processes and marketing strategies. He hopes to get a deeper understanding of the operation of industries like coal plants. Gregory is a quick learner and unafraid to take on leadership responsibilities. He thinks unconventionally and is always a good analytic board to bounce ideas off of.

Hector Garza Rodriguez - Hector plans to contribute his dedication and hard work to the project. The primary thing that he wants to develop is communication with all team members in order to learn new things about them. He plans to learn economic, environmental, and industrial impacts of power plant technology. He thinks that this project has a lot of potential because it analyzes future technologies that can improve the environment.

Michael Haddad - Michael's bachelor's degree is in physics and he is currently in his last semester of graduate studies in the Industrial Technology and Manufacturing Operations program. He has prior professional experience working in laboratories (semiconductor and materials science) but much of the time between his two degrees was spent in sales. He prefers to work in a creative capacity geared towards innovation. He expects that this project will produce useful information for Sargent and Lundy, as well as, invaluable interdisciplinary experience for himself. He is skilled in Excel, materials testing methods, and computer hardware/software troubleshooting.

Ryan Kyle - Ryan's strengths are his hard work and dedication to tasks that need to be done and his knowledge of chemical engineering. Ryan hopes to gain knowledge of sulfur capture technologies as well as building his teamwork skills by participating in IPRO 302.

Michael Mongillo - Michael Mongillo is a third year Applied Mathematics major. He has strong research and analytic skills. Over the course of this IPRO he will learn to effectively report and present research to a group of fellow researchers. He expects to research an interesting question of how to effectively make use of a new technology.

Ryan Murphy - Ryan Murphy is a fifth year architecture major and electrical engineering minor. Because of his experience in the Architecture and ECE departments, he is able to see problems from multiple viewpoints. He is also skilled in presenting and preparing graphics. Over the course of this IPRO, he will learn how to effectively manage a group of people from different backgrounds for a single purpose. He expects this to be a challenging but rewarding experience for real world situations.

Oluwaseun Shonubi - Seun is a fourth year electrical engineering student. He is a strong team worker, and is also quick at understanding new technologies and ideas. He hopes to learn how sulfur capture works in coal power plants, as well as understanding how the national sulfur market operates.

Bryce Swillum - Bryce is a 4th year chemical engineer and already possesses a basic knowledge of the unit operations involved in sulfur capture and coal plant operation. Bryce looks to expand this knowledge and to identify the economic impacts involved in sulfur production from its extraction in the plant. Bryce expects to gain this knowledge and hopes this project will provide Sargent and Lundy with the necessary information to make a well advised decision on the future of the coal-fired/gasification power plants.

Brian Wolber - Brian is a fourth year business major, specializing in entrepreneurship. He plans to pursue a career in the energy industry. He is skilled in creating presentations, including powerpoints.

Terrika Worthon - Terrika Worthon is a fifth year Mechanical Engineering student. She posses good communication skills and a non bias approach when tackling different problems. She hopes to gain knowledge about the different sulfur capture technologies available along with investigating the beneficial usage of sulfur byproducts in society.

2. TEAM PURPOSE AND OBJECTIVES

A. Team Purpose

Our team will investigate the net impact of sulfur capture technologies used in current and next generation power plants in the United States. We will use this knowledge to determine which sulfur capture technologies produce the greatest benefit for industry and society and to find the marketability of the sulfur byproducts created in these power plants.

B. Team Objectives

1. Determine which technologies have the lowest costs and meet environmental standards.

2. Investigate current and developing sulfur capture technologies used in coal power plants.

3. Determine the marketability of the sulfur released from coal.

3. BACKGROUND

A. Sponsor

The sponsor for this IPRO is Sargent & Lundy,LLC which is based in Chicago, Illinois. This company has extensive consulting, engineering, and design experience with electric power generation and power delivery projects worldwide. Sargent & Lundy provides consulting, engineering, and project development services for all types of fossil-fuel, nuclear, and renewable power generation and power delivery projects. Their website is *www.**sargentlundy**.com.*

B. User Problems

Some of the problems that the project faces are whether there are environmental impacts which we as a class might not have foreseen concerning coal technology and its byproducts. Another problem that might arise is the market place implications when possibly flooding the market with sulfur based products. Another problem that we as a group may face is whether the data that is found will actually be of any use. Or whether anybody will have the technical skills to analyze the data accumulated regarding sulfur by products.

C. Technology

The group would have to decide which sulfur capturing technology would be of the most benefit. In regards to combustion plants, Flue Gas Desulfurization (FGD) methods are used, resulting in a gypsum ($CaSO_4$) byproduct.

Flue gas desulfurization units (FGDs) remove the sulfur as a secondary unit. After the production of energy through the combustion of coal (primary unit), the flue gas is then 'cleaned'. There are several chemicals currently in use for scrubbing the gas—these include: lime, limestone, magnesium hydroxide, and seawater. The primary products of sulfur dioxide with these chemicals are a solid precipitate and either water or carbon dioxide. The solid precipitate can then be removed by fly ash removal methods. In general, there are two different types of FGDs: wet and dry scrubbers. Wet scrubbers contact the exhaust with chemical solutions as listed above. Dry scrubbers contact the exhaust with dry chemical slurries. The simplest type of tower is a spray tower, which consists of many sprayers throughout the length of the tower to contact the flue gas with the chemical solution. Other types include venture-rod scrubbers, packed bed, mobile bed, and plate scrubbers.

Desulfurization in Integrated Gasification Combined Cycle (IGCC) plants can be achieved through amine scrubbing technologies, varieties of which will be analyzed. The sulfur must be removed from the gas stream before it enters the turbine. Otherwise, sulfur present would corrode the turbine and result in a much shorter unit operation life span.

The amine scrubber process produces as much sulfur as FGDs, but in different forms, mostly sulfur dioxide or hydrogen sulfide. These can also be used to produce commercial sulfuric acid, cement, and a wide variety of other products.

Once the sulfur capturing technology is chosen along with its appropriate by product we can then start analyzing the market place implications and environmental problems that might arise along with all the data that we have collected.

D. Historical Success and Failure

Our IPRO is somewhat based on the assumption that IGCC power plants will become prevalent in coming years. Currently, there are no commercially operating IGCC power plants, so the new forms of sulfur generated by their removal technologies have not been integrated into the sulfur market. We will not be the first group of people to look into this problem, but so far no predictions for the marketability of this sulfur have been either proven or disproven.

E. Ethical Issues

There are several ethical issues involved with this IPRO. First and foremost, this IPRO is a research oriented IPRO. This will bring about ethical issues based on academic dishonesty and will require thorough citing of resources used throughout the research process during the course of the semester. Also, any solution that is created will have to be environmentally sound. Any sulfur that doesn't make it into the marketplace has to be disposed of properly.

F. Business or Societal Costs

The problem is to evaluate the impacts of various sulfur capture technologies in both business and industrial aspects. Costs to business may include a depreciation of the value of sulfur due to an influx of sulfur products into the current market. Further, improper disposal methods of sulfur may result in an increase in the amount of sulfur in the environment. This sulfur would react to produce harmful compounds such as SO_x and acid rain. Acid rain would cause many dollars in damages to both society and business as it corrodes most metals that it comes into contact with. SO_x are harmful air pollutants that cause asthma like symptoms and in the most extreme cases suffocation and death. A reduction of sulfur present in the environment, thus, would have many beneficial business and societal effects.

G. Implementation Outline

The chosen methods of SO_x capture and removal in coal based power plants first and foremost depends upon whether the plants use coal to achieve combustion or gasification. In regards to combustion plants, Flue Gas Desulfurization (FGD) methods are used, resulting in a gypsum ($CaSO_4$) byproduct. Desulfurization in Integrated Gasification Combined Cycle (IGCC) plants can be achieved through amine scrubbing technologies, varieties of which will be analyzed. The quantity or prevalence of gasification plants versus combustion plants in the United States will be a factor in determining the overall utility and benefit of any proposed amine scrubbing solutions as combustion plants are traditionally more common.

A comparative study of the varieties of the amine scrubbing technologies in regards to sulfur byproducts and their potential uses will allow the team to discern between the economically, environmentally, and socially feasible solutions and otherwise. There is the possibility that the applicability of certain desulfurization methods will be suited to certain power plants of either type more than other plants based on plant size, ease/cost of retrofitting, available end-use opportunities for excess sulfur and/or sulfur based compounds. The possible sulfur compound byproducts that the team may analyze for commercial use, export, or disposal are elemental sulfur, SO_x , gypsum ($CaSO_4$), hydrogen sulfide (H_2S), sulfuric acid (H_2SO_4) and possibly others.

H. Research on Similar Solutions

Market analyses of sulfur compounds as commodities will be of great significance in regards to understanding the ramifications of the introduction of large amounts of sulfur compounds into commercial circulation. Current outlets for sulfur byproducts are landfills, cosmetic products, fertilizers, drywall, and the industrial use of sulfuric acid. In addition to determining the efficacy of these outlets will possibly be innovative suggestions for future consideration. Technologies designed to achieve similar desulfurization effects have been suggested and even patented but have yet to be as proved as FGD or Amine scrubbing.

I. Critical Documents

There are no documents that provide a full framework for our project.

4. TEAM VALUES STATEMENT

A Expected Behavior

1. Team members must show up to class. This is the forum for all problems and research important to the entire project team. The classes are short, so members need to show up on time for each class. Any member who needs to miss a class should contact his or her subteam leader beforehand.

2. Team members will be expected to meet with their subteams on a regular, scheduled basis. All issues will not be able to be resolved during class, and there will be issues that apply only to individual subgroups that must be addressed in subgroup meetings.

3. If team members have disagreements with each other, they should first attempt to solve them on their own, before they escalate to something that could disrupt the group. If a compromise cannot be found, the disagreement should be taken to the team leader.

4. All team members are expected to stay in contact with the group and up to date with the business of the IPRO. Team members should read their email and check iGroups on a regular basis.

B Team Discussion

1. All team members should take part in class discussions. Especially during the research phase, members will all be researching different topics that are closely related to the research topics of other members. The value of working in a group is sharing this information for the benefit of all.

2. Team members need to do enough individual work or research to make the meetings useful. The IPRO meetings are not going work sessions; they will be times to discuss the work that has already been done and to organize the work that is left to do.

3. Argument should be encouraged on controversial or important issues. However, no argument should devolve into personal attacks; discussions must be kept civil to be productive.

II. PROJECT METHODOLOGY

1. WORK BREAKDOWN STRUCTURE

A. Problem Resolution

1. Process

We will start by researching the current condition of the coal power industry in the United States. We will also research the state of the US sulfur market. This will give us a baseline for sulfur removal and processing as well as inform us of what problems need to be addressed to market sulfur products. Assuming that coal gasification technology grows in the near future, we will extrapolate the decline of conventional coal power plants and the increase in gasification power plants. From there, we will study the potential uses of the different forms of sulfur generated by gasification technology.

2. Major Tasks

These are identified in the Gantt Chart.

3. Testing, Analyzing and Documenting

Our IPRO is research based, and there will be no physical testing of our solutions. However, our solutions and proposals will be backed up by the research that we do. Any extrapolations are, by nature, not provable, but they will be reasonable according to our research.

4. Feasibility

Our Gantt Chart lists tasks in order of when they need to be completed. Our IPRO cannot be a comprehensive look at coal desulfurization, as our experience won't allow us to do so. Our research will be limited to the time we have, rather than attempting to research comprehensively. The scale is limited to allow us to look into the problem in some detail, and the schedule will allow us time to do so.

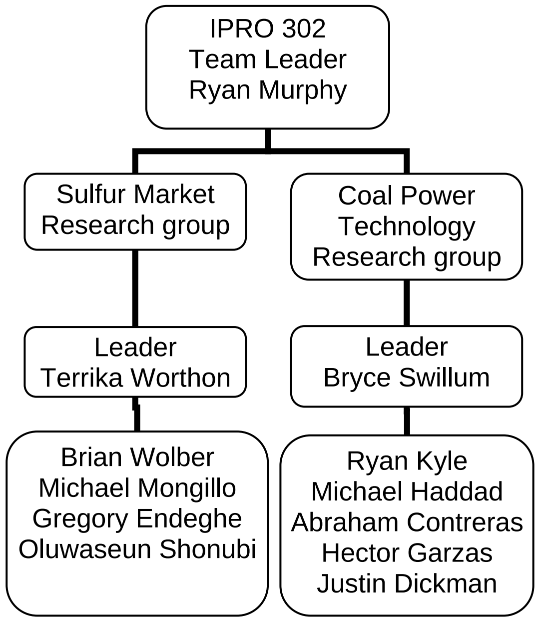
B. Team Structure

1. Team Leaders

Team Leader - Ryan Murphy
Power Technology Subgroup Leader - Bryce Swillum
Sulfur Market Subgroup Leader - Terrika Worthon

Additionally, subteams will be created at a later date for the deliverables.

2. Team Hierarchy



C. Gantt Chart

Included in end of file

2. EXPECTED RESULTS

A. Expected Activities

Our IPRO will consist mainly of research and analysis based on that research. As indicated in our Gantt Chart, the research will initially be based on current conditions, and we will move into future conditions. Our contribution will be to synthesize this data into a set of ideas for what to do with expected sulfur output. After that, we will document our solutions and deliver them to the client.

B. Expected Data

1. Current industrial output of sulfur categorized by amount, form, and destination
2. Current market values, uses, and sources of sulfur categorized by form
3. Basic characteristics of conventional coal power plant operation
4. Trends of growth and change in sulfur markets
5. Basic characteristics of new technologies for removing and converting sulfur
6. Extrapolated data on sulfur production and demand

C. Potential Products

This section does not apply to our IPRO.

D. Potential Outputs

The output for our IPRO will be an idea for how to deal with projected amounts and forms of sulfur. It is beyond the scope of our IPRO to test actual products that would do this, but our ideas could be implemented in the future if gasification technology takes over the coal power plant market.

E. Deliverables

Our IPRO will deliver a report documenting the work we have done and the solution we have come to. This report will be given to the IPRO office as well as our sponsor, Sargent and Lundy.

F. Challenges

Our group will face many challenges while researching and coming up with our solution. The IPRO itself is founded in the assumption that gasification technology, a proven but currently unused process, will become dominant in the coal power market. Past that assumption, we will have to make many extrapolations and predictions based on current and past numbers. With new technology emerging and markets that can vary widely, these predictions not be exact. We will have to come up with a system of determining how reasonable our assumptions are.

We will also face the problem of scope creep. Already we have limited ourselves to the sulfur byproduct of gasification plants, and we will not be looking in too much depth into the actual operation of these plants. We have also limited ourselves to the US market, which we feel will be more manageable and more likely to have reliable data. We will continue monitor the scope of our work, and we will have to confine ourselves to a field that we can reasonably research in the course of one semester.

3. PROJECT BUDGET

Since our project is a research-based project, we will not present a budget for the IPRO office. No money will be spent on any kind of product testing or trips, and whatever costs are incurred for food at meetings will be carried by the team members.

4. DESIGNATION OF ROLES

Minute Taker - Bryce Swillum: Will be responsible for taking minutes of class discussions and decisions, and will post those minutes on iGroups at the end of the class period.

Agenda Maker - Ryan Murphy: Will be responsible for deciding what needs to be accomplished during meetings. If any team members have submitted tasks to be done in the meeting, the agenda maker will decide whether to put them on the agenda. Lastly, the agenda maker will print hard copies of the agenda to be handed out and followed during class.

Time Keeper - Oluwaseun Shonubi: Will be responsible for keeping the team leader on schedule to accomplish the items on the agenda.

Igroups Moderator - Ryan Kyle: Will be responsible for keeping the iGroups page organized and clear.

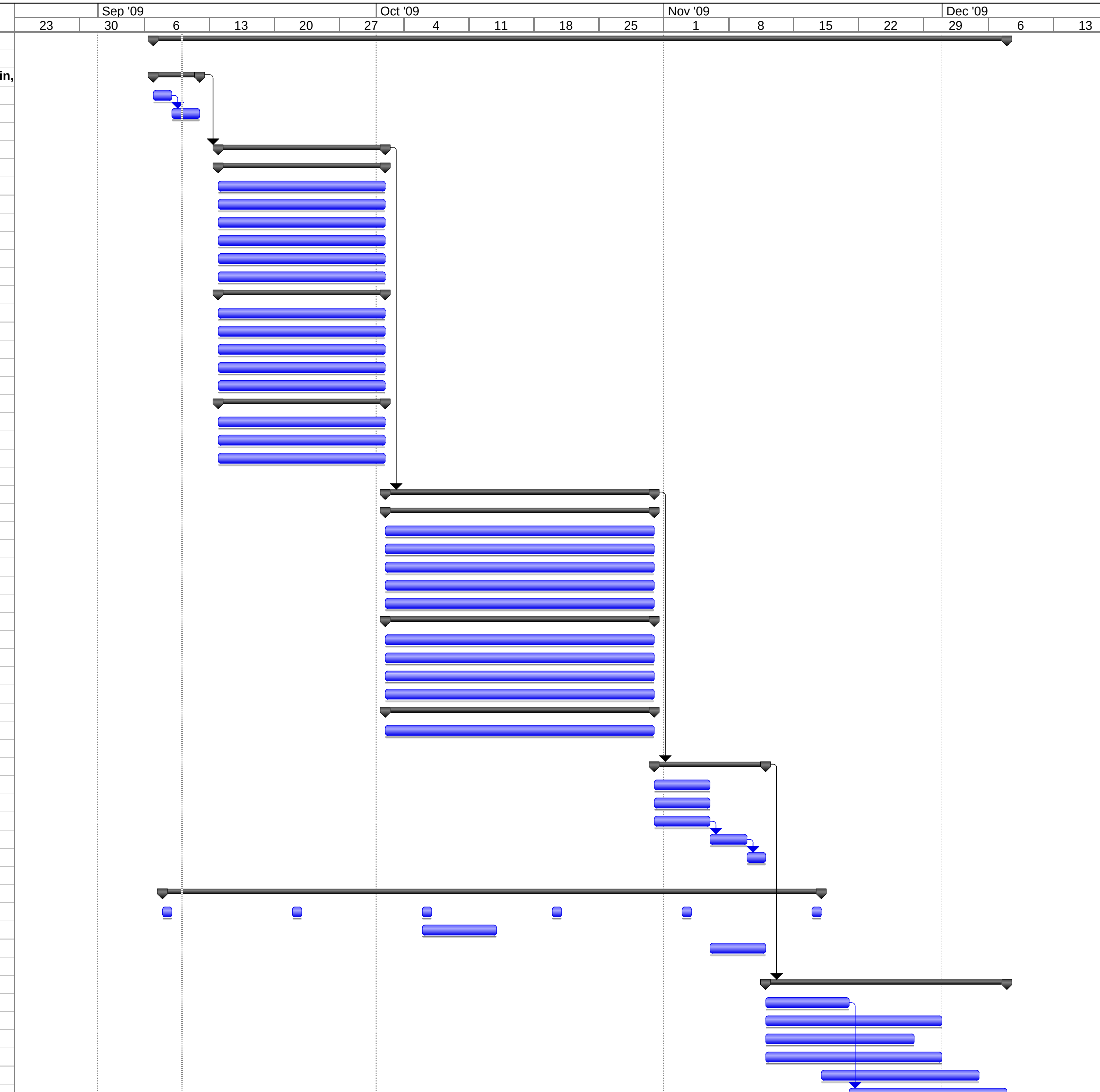
III. SOURCES

"Sulfur." Encyclopædia Britannica. 2009. Encyclopædia Britannica Online. 10 Sep. 2009

"Flue Gas Desulfurization", 2009. http://www.coal.sgs.com/flue-gas-desulfurization.htm

"Flue Gas Desulfurization for SO2 Control" http://www.iea-coal.org.uk/site/ieacoal_old/clean-coal-technologies-pages/clean-coal-technologies-flue-gas-desulfurization-fgd-for-so2-control-?

ID	Task Name	Duration	Start	Finish	Resource Names
1	**IPRO 302**	**58 days?**	**Mon 9/7/09**	**Mon 12/7/09**	
2					
3	**Project Plan**	**5 days**	**Mon 9/7/09**	**Fri 9/11/09**	**Ryan K,Abe,Brian,Bryce,Greg,Hector,Justin,**
4	Clarify IPRO purpose and goals	2 days	Mon 9/7/09	Tue 9/8/09	
5	Split into subgroups for project plan sections	3 days	Wed 9/9/09	Fri 9/11/09	
6					
7	**Research - Existing Conditions**	**14 days**	**Mon 9/14/09**	**Thu 10/1/09**	
8	**Current coal power and sulfur conditions**	**14 days**	**Mon 9/14/09**	**Thu 10/1/09**	**Bryce,Ryan K,Mike H,Abe,Hector,Justin**
9	Current coal power technology	14 days	Mon 9/14/09	Thu 10/1/09	
10	Conventional powerplant operation	14 days	Mon 9/14/09	Thu 10/1/09	
11	Flue scrubbers/ sulfur removal tech	14 days	Mon 9/14/09	Thu 10/1/09	
12	Form of sulfur generated	14 days	Mon 9/14/09	Thu 10/1/09	
13	Amount of sulfur generated	14 days	Mon 9/14/09	Thu 10/1/09	
14	Profitability of sulfur products vs. cost of removal	14 days	Mon 9/14/09	Thu 10/1/09	
15	**Current markets for sulfur**	**14 days**	**Mon 9/14/09**	**Thu 10/1/09**	**Terrika,Brian,Mike M,Greg,Seun**
16	Cost of sulfur in various forms	14 days	Mon 9/14/09	Thu 10/1/09	
17	Uses of sulfur in various forms	14 days	Mon 9/14/09	Thu 10/1/09	
18	Point of origin for commercial sulfur	14 days	Mon 9/14/09	Thu 10/1/09	
19	Import/Export to United States	14 days	Mon 9/14/09	Thu 10/1/09	
20	Disposal of sulfur	14 days	Mon 9/14/09	Thu 10/1/09	
21	**Current environmental regulation**	**14 days**	**Mon 9/14/09**	**Thu 10/1/09**	
22	Allowable release into atmosphere	14 days	Mon 9/14/09	Thu 10/1/09	
23	Allowable disposal techniques	14 days	Mon 9/14/09	Thu 10/1/09	
24	Fines for pollution	14 days	Mon 9/14/09	Thu 10/1/09	
25					
26	**Research - Future Conditions**	**21 days**	**Fri 10/2/09**	**Fri 10/30/09**	
27	**New Technology**	**21 days**	**Fri 10/2/09**	**Fri 10/30/09**	**Bryce,Ryan K,Mike H,Abe,Hector,Justin**
28	IGCC power plant operation	21 days	Fri 10/2/09	Fri 10/30/09	
29	Amine scrubbers	21 days	Fri 10/2/09	Fri 10/30/09	
30	Other powerplant sulfur removal techniques	21 days	Fri 10/2/09	Fri 10/30/09	
31	Form and amount of sulfur generated	21 days	Fri 10/2/09	Fri 10/30/09	
32	Technology for converting form of sulfur	21 days	Fri 10/2/09	Fri 10/30/09	
33	**Projected Market**	**21 days**	**Fri 10/2/09**	**Fri 10/30/09**	**Terrika,Brian,Mike M,Greg,Seun**
34	New/Growing Uses	21 days	Fri 10/2/09	Fri 10/30/09	
35	New/Growing Sources	21 days	Fri 10/2/09	Fri 10/30/09	
36	Benign Disposal techniques	21 days	Fri 10/2/09	Fri 10/30/09	
37	Possible growth in exports	21 days	Fri 10/2/09	Fri 10/30/09	
38	**Projected regulations**	**21 days**	**Fri 10/2/09**	**Fri 10/30/09**	
39	Allowable disposal/pollution/fines	21 days	Fri 10/2/09	Fri 10/30/09	
40					
41	**Solution**	**9 days**	**Sat 10/31/09**	**Wed 11/11/09**	
42	Estimate market prices for forms of sulfur	5 days	Sat 10/31/09	Thu 11/5/09	
43	Estimate size of markets	5 days	Sat 10/31/09	Thu 11/5/09	
44	Estimate capacity/costs of all sulfur sources	5 days	Sat 10/31/09	Thu 11/5/09	
45	Determine if sulfur will be commodity or waste	2 days	Fri 11/6/09	Mon 11/9/09	
46	Determine most profitable way of dealing with sulfur	2 days	Tue 11/10/09	Wed 11/11/09	
47					
48	**IPRO communications**	**52 days**	**Tue 9/8/09**	**Tue 11/17/09**	
49	**Internal Presentations**	**52 days**	**Tue 9/8/09**	**Tue 11/17/09**	
56	Mid-Term Reviews (10-minute project updates by team	6 days	Tue 10/6/09	Tue 10/13/09	
57	Individual Ethics Reflection Paper	4 days	Fri 11/6/09	Wed 11/11/09	
58					
59	**Final Reports/Presentations**	**19 days?**	**Thu 11/12/09**	**Mon 12/7/09**	**Subgroups TBD**
60	Draft Final Report	7 days	Thu 11/12/09	Fri 11/20/09	
61	Exhibit/Poster	14 days	Thu 11/12/09	Mon 11/30/09	
62	Abstract/Brochure	13 days?	Thu 11/12/09	Fri 11/27/09	
63	Presentation	14 days?	Thu 11/12/09	Mon 11/30/09	
64	IPRO Projects Day	14 days	Wed 11/18/09	Fri 12/4/09	
65	Final Report	12 days	Sat 11/21/09	Mon 12/7/09	



Project: IPRO302
Date: Thu 9/10/09

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline