IPRO 302 Project Plan
Spring 2009

Zero Liquid Discharge
From
Coal-Fired Electric Generation Facilities

Advisors: Don Chmielewski & Myron Gottlieb

1. Team Information

A. Team member roster: See #9
B. Team member strengths, needs and expectations: See #9
C. Team identity: See #4

2. Team Purpose and Objectives

The objective of this project is to identify, evaluate, and prioritize technologies that can be used to achieve zero discharge in a 500 MW power plant using Powder River Basin coal. To accomplish this mission, we will:

1. Determine the water balance around a typical facility
2. Perform a qualitative assessment of the viability of the three technologies above toward meeting zero discharge.
3. Determine the size, first cost and operating cost for each combination of zero discharge unit operations considered
4. Identify creative options for reusing treated discharge water within the plant
5. Identify emerging technologies that might play a major role in the future.

3. Background

A. Sargent & Lundy is a company specializing in professional service for clients seeking power and energy. They have been exclusively serving the electric power industry and related businesses for 118 years, and their work is always on the forefront of modern technology, helping companies increase their business by serving all of their power needs, present and future.

   Sargent & Lundy provides complete consulting, engineering, and project development services for all types of fossil fuel, nuclear, and renewable power generation and power delivery projects. Their comprehensive capabilities provide clients and partners with a thoroughly reliable source of expertise. Sargent & Lundy is headquartered in Chicago, Illinois with project team locations worldwide.

B. Problems include the handling of the liquid discharge devices, which might require specially trained workers / maintainers, therefore increasing the maintenance and operating cost of the power plant. Furthermore, users have to deal with space limitation problems as these devices (evaporation pond as an example) take up quite an amount of space. User problems are more along the lines of decreasing emissions and staying within or below regulatory guidelines. In addition, to provide safe environment for employee and reduce costs while increasing efficiency.

C. There are several types of technology currently employed in closed-loop near-zero liquid discharge facilities; namely, deep wells, evaporation ponds and brine concentrators. There are also a number of newly emerging technologies such as nanofiltration systems, industrial strength high integrity V*SEP membrane systems and/or reverse-osmosis technology and combined $CO2/O2$ systems. Crystallizers can also be employed in conjunction with a brine concentrator in a closed loop system to improve the quality of recovered water as well as to collect in solid form waste materials that can be re-sold for commercial value (e.g. mercury). It is unclear the effect that naturally occurring ionic charge differences in the aqueous wastewater environment will have on the membrane-potentials and the nanofiltration systems, should those be employed, but the currently available research and information would suggest great potential for a maximally efficient low-cost water treatment and thus re-use solution.

D. 1. Zero Discharge – Treatment Options for Textile Dye Effluent: A Case Study at Manickapurampudur Common Effluent Treatment Plant, Tirupur, India
   Presented in 2004
   Uses reverse osmosis for recovery of pure water to be recycled.
   - Nano-filtration
   - Multiple effectors evaporator
   - Solar pond for evaporation
   - Windmills for power generation to cater electrical needs for reverse osmosis / filtration / evaporator

   Uses Multiple Effect Evaporator to evaporate effluent (wastewater) as zero-discharge method but it consumes large quantity of wood as a fuel, which will enhance wood demand and carbon dioxide emission into the atmosphere.
   - Requires government funding. Attempted to apply for financial aid but are unsuccessful

   2. Treatment of saline wastewater for zero discharge at Debiensko coal mines in Poland
   - The composition and the salinity of the mine drainage wastewater from Debiensko and Budryk have been changed considerably since the original planning and design. This primarily has an influence on the operation of the RO section, but it is now possible to mix the two wastewaters to a desired degree in order to optimize the operation of the RO section and to increase the operation flexibility.
   - Success for zero discharge. (1995)

   3. New Logic's VSEP pilot equipment on wastewater provided by California Linen Rental Co., a major industrial laundry located in Oakland, California

- "Zero-Discharge" laundry Wastewater treatment successful
- After processing a total of 2,757 gallons of the industrial laundry wastewater, only 1 gallon of fresh water was required for make up water. The remaining 2,756 gallons of recycled clean water is available for re-use. (January 1999)

E. The most basic responsibility of water utilities is to support public health, safety, and economic well-being by providing an adequate supply of safe water. Therefore, the first ethical issue of wastewater in coal fired electric generation facilities is public health. Wastewater, which has higher concentrations of nitrite, ammonia, and organic nitrogen than most drinking water supplies, increases the likelihood of certain water quality problems. The second issue is cost. To eliminate all wastewater streams, consumers need to pay more money. Water rate increases can also have a negative income on low-income ratepayers in more wealthy payers. Where all consumers pay the same water rate, a choice that benefits the economy as a whole may be disproportionately burdensome for low-income ratepayers.

F. The respective technologies mentioned display a very diverse and variable set of costs, both business and societal making the solution extremely circumstantial and location dependant. Deep well technology, for instance can carry an initial cost of anywhere from $1-$6,000,000 for an approximately 500-700 MW facility. Operating costs vary greatly depending upon location and age of the facility. The issue of the earth's subterranean environment, rock porosity, water table/aquifer levels, naturally trapped gasses or toxins, etc. is of high concern to this method of liquid waste management.

   The popular evaporation pond method carries an initial cost in the range of $750,000-$1,200,000 for a 500MW plant, depending largely on the cost and availability of land and the natural ambient humidity of the area. Over-flows, leaks, habitat destruction and harm to native flora and fauna of the land area in question remain large concerns with this technology. Fines for health and environmental violations are heavy and consequences to both environmental and human health are often hazardous and potentially fatal.

   Brine concentrators typically require a high initial capital investment but work efficiently and at relatively low operating cost. The operation cost tends to run in the neighborhood of $4.52/1000 gallons of recovered water in power plants in the southwestern United States currently using this technology. These brine concentrators are very safe, provide a high-purity source of recovered water that can be reused in the plant and sometimes can offer the recovery of solids, minerals, or otherwise substances which might be re-sold for commercial value (such as mercury, often used in thermometers). These benefits help to offset the cost of this technology and the likelihood of fines for contamination or mal-operation are very low.

   Many new technologies such as VhSEP membrane systems, nanofiltration, reverse osmosis and forward osmosis systems are currently becoming available. There is less information available about the long-term operation costs, conflicts or benefits of these systems, but preliminary observation would suggest they are of very high efficacy (>99% water recovery for closed loop system) and safety.

   The initial capital costs for a Biomass/CO2-capture/recovery facility tend to run around 16 million (or $20,532,800); averaging $50-60 per metric ton of CO2. Over a 15-20yr period this raises operating costs only $0.02/kWh and has a deprecation rate of $0.0125/kW. An important cost to keep in mind from both the business and societal standpoint is a rise in the consumer and manufacture cost per kW of electricity. To address the societal standpoint, rising energy costs means more financial strain on families and small businesses, or the need to reduce energy use (something that is not always particle to achieve from a whole community). A change in the unit price of energy will disrupt profit margins by shifting consumer demand and availability dynamics.

G. The team will be looking into three different solutions for the discharge water problem in coal-fired power plants: evaporation pond, deep well injection, and brine concentrator. The listed solutions will be assessed qualitatively and quantitatively based on size, costs, effectiveness, feasibility, etc. In addition to those solutions, the team will look in emerging technologies in this field or look at other possible solutions that will help clean or reuse water rather than achieving the zero-liquid discharge objective. All research is based on the primary research of the water balance of the power plant which affects what the team decides to do for the waste water discharge problem. The results will be gathered research on each solution and then further detailed information on the solution the team decides for eliminating waste water streams.

H. There are a number of different examples of zero liquid discharge (ZDL) technology being implemented in coal fired power facilities. In power plants ranging from Australia to Italy to California, a variety of methods are being used to achieve ZDL.[1]

U.S. Environmental Protection Agency *Steam Electric Power Generating Point Source Category: 2007/2008 Detailed Study Report* http://www.epa.gov/guide/304m/2008/steam-detailed-200809.pdf

IDS Water *Aquatech Commissions FGD Wastewater Zero Liquid Discharge Systems for ENEL in Italy* http://www.idswater.com/water/asia/wastewater/3633/pressrelease_content.html

Water Science and Technology: Water Supply *Water Reuse and Zero Liquid Discharge: A Sustainable Water Resource Solution* http://www.iwaponline.com/ws/00304/0097/003040097.pdfAttach any critical documents that provide a particularly useful framework or context for the problem(s).

4. Team Values Statement

To be proactive and take initiative.
To treat one another with mutual respect and fairness.
To be punctual and responsible for our commitments.
To show enthusiasm and energy as we accomplish difficult tasks.
To take pride in learning from others, testing our abilities and boundaries, and willing to admit mistakes.

We value openness in discussing any idea and honesty in tackling any problem, and we will use the full extent of both technical (iGroups, email) and non-technical (team/sub-team leaders, group discussion) means to communicate while developing solutions.

HYDROPURE
Clean Water. Clean Energy. Clean Living.

5. Methodology / Brainstorm / Work Breakdown Structure

A. Identify, evaluate and prioritize technologies that can be used to achieve zero discharge in a 500 MW power plant using Powder River Basin coal.

B. In order to accomplish the problem defined in part A, we must do the following:
First, the current process of the waste water from power plants must be completely understood to make adequate progress during the duration of this project. A trip to a coal-fired power plant will facilitate this understanding. Further research and inquiry will provide the basis to determine the amount of water that is discharged in a 500 megawatt power plant.

   Also, research will be done on possible technologies that eliminate waste water discharge. Groups will research the efficiency of the suggested methods, the cost effectiveness, and the practical application in current power plants. Simultaneously, other groups will be researching other technologies that were not suggested. Then, all technologies will be evaluated based on efficiency, spatial availability and cost.

C. All possible solutions will be analyzed with the sponsor's needs in mind. The criterion for a feasible solution includes cost, available space, and efficiency.

D. The sub-team leader of each sub-team is responsible for conveying the research done by their group to all the other members of this IPRO. A final, detailed summary of a sub-team's research will be uploaded into iGROUPS.

E. After presenting the findings of their research, each sub-team will hold a discussion among the other group members about the efficiency, practicality, and feasibility. This process will be done with each technical option researched.

F. A sub-team will be created and assigned the task of generating deliverable reports. The rough draft of the deliverable will be posted on iGROUPS and available for critique by all team members and the instructors of the course.

G. Not Applicable

6. Expected Results

A. IPRO 302's expected activities are to visit a coal-fired power plant sometime in February and to contact power plants with any of the listed zero-liquid solutions in order to get an idea of productivity, efficiency and cost. If the power plant is close enough, we as a team will visit one or more (if possible). Other activities are creating a website to supplement our project's mission and showing what a zero-liquid discharge system would do for a power plant.

B. We expect to discover where water is most contaminated in the coal fired process, how much water is contaminated in a 500 MW plant, how and why the water is contaminated, and which of the possible zero-liquid discharge solutions is most efficient and cost effective. An innovative approach towards the project is instead of trying to eliminate waste water; we could possibly try to do some research on how to reduce/eliminate waste water production. Through research, we expect to know more about each solution and that impacts that have on the power plant efficiency and environment. In addition to those solutions, we will know a lot more about the process of coal fired power plants by visiting power plants in order to cement our knowledge about zero-liquid discharge systems.

C. Some potential products resulting from research and testing are a website with details on the specific zero-liquid discharge solution we choose, new innovative solutions with emerging technology, and a proposal or summary for our sponsor and other companies with the information we gathered.

D. Our potential outputs through the execution of assigned tasks are to gather information on zero-liquid discharge systems to better inform team members and to share that information with others outside of our team. The output of each individual is to gain knowledge and the team output is to work together to put together the information in easy and understandable manner.

E. Our expected results in terms of deliverables are to clearly present our research through a website and by writing a detailed plan to show what kind of impact a zero-liquid discharge system would have on the environment and the power plant

F. Some challenges could be the lack of research on zero-liquid discharge which severely hinders the IPRO project's purpose/mission. Another challenge of the team is to find balance between a perfectly environmental friendly power plant and a cost saving/efficient power plant. Possible risks could be not getting enough substantial evidence/research for supporting our zero-liquid discharge solutions and/or choosing a solution that could have long term affects that have not been discovered yet. Another big risk is to bypass the suggested technologies and to come out with an innovative new idea which might not work in the real world due to the lack of professional knowledge (the team) in power plant operation.

G. Proposed solution will be reported to our sponsors, Sargent & Lundy who may or may not use the data we collected to add a zero-liquid discharge system to their power plants. Our research may also help other power plants to decide on a zero-liquid system and/or teach others interested in the coal power plant system/new emerging technologies.

7. Project Budget

Supplies (Lab supplies, office supplies, etc.)

$75

$75 covers extraneous supplies that will certainly be needed. The IPRO poster is covered by the IPRO office, but our team believes many non-poster costs are to be expected. These include the costs of other books and articles (that have not been taken into account by our equipment needs) that may be necessary to purchase along the way, as well as business cards, copying, and other printing/development needs.

Equipment (Purchase materials and/or parts for testing or construction.)

$170

Our team found that the book "Steam: It's generation and it's uses" by Babcock and Wilcox would be instrumental in our research. The following sites are for ordering the book:

http://www.babcock.com/library/steam.html

http://www.babcock.com/library/pdf/steambook.pdf

It is an immense book on coal-fired power plants, their components, and it includes many of the utilities we need to comprehend. Also, an article by the American Society of Civil Engineers ($18+shipping) had a lot of information on the subject that we would like to purchase.

Services (Printing, rentals, consulting, patent searching, etc.)

Travel/Meetings (Transportaion costs, meals, conference passes, etc.)

$250

We will be taking a trip to a Midwest Generation coal-fired power plant for a personal tour of a plant similar to the one we will be analyzing; to ask questions regarding the many processes involved in the plant and to discuss possible options for zero liquid discharge with experts at the plant. Costs for this trip include the gas mileage (for 3 vehicles) to the plant and back, as well as a meal while away from school for the trip. This should cost no more than $100 (budget below shows $96.79).

Driving directions to Crawford Station, 6.2 mi – about 9 mins (up to 20 mins in traffic)

From:	3241 S Federal St Chicago, IL 60616	1. Head north on S Federal St toward W 31St	0.2 mi
		2. Turn left at W 31st St	289 ft
		3. Turn right at S La Salle St	0.3 mi
To:	Crawford Station 3501 S Pulaski Rd	4. Take the ramp on the left onto I-90 W/I-94 W	0.5 mi
		5. Take exit 53B for Stevenson Expy/I-55 S	0.6 mi
		6. Merge onto I-55 S	4.0 mi
		7. Take exit 287 for Pulaski Rd toward 4000 W	0.3 mi
		8. Turn right at S Pulaski Rd	0.4 mi
		Destination will be on the right	

<u>Budget for Midwest Generation Power Plant Trip</u>

Driving: 6.2 miles one way, two directions, 3 vehicles = 37.2 miles total

Federal rate for 2008 is 50.5 cents per mile.

Total reimbursement for team equals 37.2 miles x 50.5 cents = $18.79

Breakfast food at $6 per person x 13 persons = $78

Total Reimbursement = $96.79

Other Meeting costs include money for occasional meals during team-building and work meetings. We will need $150 with a minimal budget of $25 per meal (for the whole team, i.e. Little Caesars). This comes out to a maximum of six team meals/meeting costs. We believe this will be a necessary component for our members when we meet on nights and weekends because of the costs associated with missing meals in the Commons, as well as the loss of time for commuters and Greeks to prepare their meals during this time. We want to have our focus on the subject of our project, and eliminate the stress of meals.

Participation Support (Incentives to participants of usability testing, product testing, user survey, focus groups, etc.)

No money is needed for participation support.

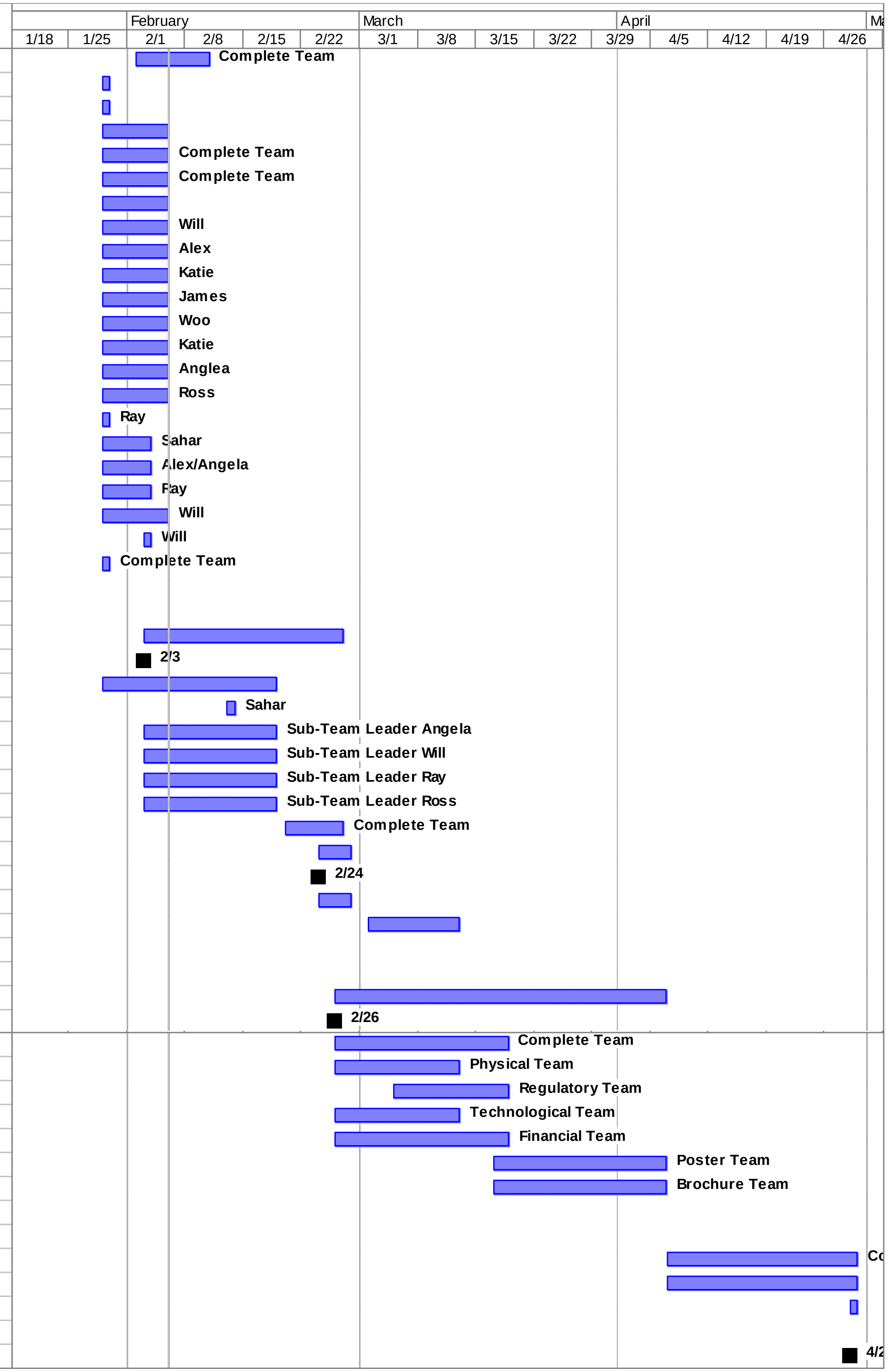
8. Schedule of Tasks and Milestone Events

Required Deliverables:	**Due Date:**
Project Plan	Feb. 6 uploaded to iKnow
Midterm Review Presentation Slides	Uploaded to iKnow on the day of review
Midterm Peer Review (optional)	Determined by instructor
Abstract/Brochure	April 27 by 9:00 am in iKnow
Poster	April 27 by 9:00 am in iKnow
Final Presentation Slides	April 29 by 12:00 noon in iKnow
Website (optional)	Determined by instructor
Determined by instructor Meeting Minutes (optional)	Determined by instructor
Final Reports	May 8 (uploaded to iKnow)
IPRO Deliverables CD (if applicable)	May 11 by 4 pm
Individual Project Analysis Report (optional)	Specified by instructor
Individual Project Logbook (optional)	Specified by instructor

Optional Deliverables:

Business Plan
Code of Ethics
Engineering Notebook
Individual Reports
Meeting Minutes
Peer Reviews
Project Notebook
Website

ID		Task Name	Duration	Start	Finish	Resource Names
1		**Project Organization**	7 days	Mon 2/2/09	Tue 2/10/09	Complete Team
2		Define the Project	1 day	Thu 1/29/09	Thu 1/29/09	
3		Determine Project Requirements	1 day	Thu 1/29/09	Thu 1/29/09	
4		Make Project Plan	6 days	Thu 1/29/09	Thu 2/5/09	
5		Team Information	6 days	Thu 1/29/09	Thu 2/5/09	Complete Team
6		Team Purpose and Objectives	6 days	Thu 1/29/09	Thu 2/5/09	Complete Team
7		Background	6 days	Thu 1/29/09	Thu 2/5/09	
8		Part A	6 days	Thu 1/29/09	Thu 2/5/09	Will
9		Part B	6 days	Thu 1/29/09	Thu 2/5/09	Alex
10		Part C	6 days	Thu 1/29/09	Thu 2/5/09	Katie
11		Part D	6 days	Thu 1/29/09	Thu 2/5/09	James
12		Part E	6 days	Thu 1/29/09	Thu 2/5/09	Woo
13		Part F	6 days	Thu 1/29/09	Thu 2/5/09	Katie
14		Part G	6 days	Thu 1/29/09	Thu 2/5/09	Anglea
15		Part H	6 days	Thu 1/29/09	Thu 2/5/09	Ross
16		Team Values Statement	1 day	Thu 1/29/09	Thu 1/29/09	Ray
17		Methodology/Brainstorm/Work Brea	4 days	Thu 1/29/09	Tue 2/3/09	Sahar
18		Expected Results	4 days	Thu 1/29/09	Tue 2/3/09	Alex/Angela
19		Project Budget	4 days	Thu 1/29/09	Tue 2/3/09	Ray
20		Schedule of Tasks and Milestone E	6 days	Thu 1/29/09	Thu 2/5/09	Will
21		Individual Team Member Assignmer	1 day	Tue 2/3/09	Tue 2/3/09	Will
22		Designation of Roles	1 day	Thu 1/29/09	Thu 1/29/09	Complete Team
23						
24						
25		**Research Team Tasks**	18 days	Tue 2/3/09	Thu 2/26/09	
26		Sub-Team Division Finalized	0 days	Tue 2/3/09	Tue 2/3/09	
27		Gather Research/Background	15 days	Thu 1/29/09	Wed 2/18/09	
28		Trip to Midwest Generation	1 day	Fri 2/13/09	Fri 2/13/09	Sahar
29		Evaporation Pond	12 days	Tue 2/3/09	Wed 2/18/09	Sub-Team Leader Angela
30		Deep Well	12 days	Tue 2/3/09	Wed 2/18/09	Sub-Team Leader Will
31		Brine Collector	12 days	Tue 2/3/09	Wed 2/18/09	Sub-Team Leader Ray
32		Emerging Technologies	12 days	Tue 2/3/09	Wed 2/18/09	Sub-Team Leader Ross
33		Analyzing & Selecting	5 days	Fri 2/20/09	Thu 2/26/09	Complete Team
34		Prepare for Midterm Report	4 days	Tue 2/24/09	Fri 2/27/09	
35		Designate Report Team	0 days	Tue 2/24/09	Tue 2/24/09	
36		Make Presentation Slides	4 days	Tue 2/24/09	Fri 2/27/09	
37		Mid-Term Review Presentation	9 days	Mon 3/2/09	Thu 3/12/09	
38						
39						
40		**Design Team Tasks**	28 days	Thu 2/26/09	Mon 4/6/09	
41		Sub-Team Division Finalized	0 days	Thu 2/26/09	Thu 2/26/09	
42		Extensive Research	15 days	Thu 2/26/09	Wed 3/18/09	Complete Team
43		Physical	11 days?	Thu 2/26/09	Thu 3/12/09	Physical Team
44		Regulatory	10 days?	Thu 3/5/09	Wed 3/18/09	Regulatory Team
45		Technological	11 days?	Thu 2/26/09	Thu 3/12/09	Technological Team
46		Financial	15 days?	Thu 2/26/09	Wed 3/18/09	Financial Team
47		Exhibit & Poster	15 days	Tue 3/17/09	Mon 4/6/09	Poster Team
48		Abstract or Brochure	15 days	Tue 3/17/09	Mon 4/6/09	Brochure Team
49						
50						
51		**IPRO Presentation Team**	17 days	Tue 4/7/09	Wed 4/29/09	Complete Team
52		Prepare for IPRO Day	17 days	Tue 4/7/09	Wed 4/29/09	
53		Presentation (IPRO Day)	1 day	Wed 4/29/09	Wed 4/29/09	
54						
55		**PROJECT COMPLETION**	0 days	Wed 4/29/09	Wed 4/29/09	



9. Individual Team Member Assignments

Name:	Major/Minor	Skills & Strengths	What We Want to Gain from IPRO 302	Teams	Assignments Done
Ashrafi, Sahar	Chemical Engineering	Microsoft Office, MATLAB, Maple, HYSYS, and LabVIEW. Very organized and good at planning.	Sahar hopes to gain a deeper understanding of emissions coming from coal-fired power plants and the various options to decrease or eliminate these emissions. On an individual basis, she would like to improve her project management skills and group task delegation.	Research Team: Brine	#5 of Project Plan
Ballard, Ray	Chemical Engineering	Written/Verbal communication, C++, Maple, Matlab, Hysis, Microsoft Office.	Ray hopes to learn and utilize a great deal of chemical engineering to study cleaner solutions for coal-fired power plants while gaining expertise in managing a team through an engineering/scientific project and presenting its results would be a great pride.	Research Team: Brine	Budget Planner, #4 & #7 of Project Plan
Beissinger, Daniel	Environmental Chemistry	I can think outside the box. I am a motivator, hard worker, and skilled in horseback riding, windsurfing, rock climbing, and competitive cycling.	Danny hopes to uses his abilities in chemistry to help the group. After two years, he has changed majors to chemistry, where he has been focusing on water resources management. He hopes this IPRO will expand his knowledge.	Research Team: Evap.	Project Plan Assembler
Hill, Ross	Mechanical Engineering	Statics, Dynamics, Materials, Thermodynamics, Technical Drawing, AutoCAD, SolidWorks, Free Hand Drawing	Ross is hoping to learn more about coal based power generation including the chemical and engineering aspects. Ross is looking forward to further developing the skills needed to work effectively in a project team as well as well as working on his time management skills.	Research Team: Emerging Tech.	Created Team Logo, Part H of PP Background
Isoda, Mitchell	Applied Math	Diff. Eq, complex analysis, computational mathematics, Matlab, Java, C++, Problem analysis and writing skills.	Mitchell is hoping to increase his skill in web design, time management, and accumulation and synthesis of research data	Research Team: Deep Well	Website Designer

Lai, James	Molecular Biochemistry & Biophysics	Working with power tools, AutoCAD, mathematics, biology, chemistry, physics, music, and history.	James hopes to learn more the economics behind this water project in addition to mechanical and chemical methods in solving it. He would also like to learn how to effectively use resources that have different backgrounds.	Research Team: Deep Well	Part D of PP Background
Latour, Catherine	Chemistry	Theoretical and applied chemistry, public speaking and technical writing,	Katie gives the group additional knowledge of chemistry. She hopes she will learn more about the construction process, specifically, obtaining permits and the environment regulations behind them.	Research Team: Emerging Tech.	Parts C & F of PP Background
Ng, Angela	Civil Engineering / Environmental Engineering	Strengths: Mathematics, English, Chemistry, Computer Skills: MathCAD, Microsoft Word, Excel, & PowerPoint, AutoCAD	Angela is a very logical thinker and is hoping to increase her creativity and abstract viewing. She is open to new ideas but prefers to pick one idea and go along with it. She also wishes to learn to improve her communication skills.	Research Team: Evap.	Minute Taker, Part G of Background, #6 of Project Plan
Ong, Alex	Civil Engineering / Structural Engineering	Mathematics, Physics, Economics, CAE, MMAE, Hand Drawing, Music, MathCAD	Having chosen this IPRO, Alex is looking forward to learn more about electric power generation, which is considered a new knowledge to him. To learn how to collaborate with people from different specializations and backgrounds.	Research Team: Evap.	iGroups Coordinator, Part B of Background, #6 of Project Plan
Pattermann, William	Civil & Architectural Engineering / Construction Management	Statics, Plumbing, HVAC, Thermodynamics, Circuits, Hydrology, Drafting, AutoCAD, MathCAD, SAP, Primavera	Even though this project pertains to only coal-fired power plants, Will is hoping to gain an understanding of how efficiency and productivity could be increased at all electric manufacturing plants. Will is really excited to gain team experience and is anxious to use his talents in a group setting.	Research Team: Deep Well	Team Leader, Master Schedule Maker, Part A of Background, #8 & #9 of Project Plan
Shin, Woo	Civil Engineering	C++, Microsoft Office, MathCAD, AutoCAD, Mathlab, Mathematics and Physics	Woo Sung is expecting to learn more about electric generation facilities and learn how to cooperate with other people.	Research Team: Brine	Part E of PP Background

Team Leader

Will Pattermann

Sub-Teams

Research Teams

A. Evaporation Pond Research Team
B. Deep Well Research Team
C. Brine Collector Research Team
D. Emerging Technologies Research Team

Extensive Research Teams

A. Physical Team
B. Regulatory Team
C. Technological Team
D. Financial Team

Design Teams

A. Poster Team
B. Brochure Team

Sub-Team Leaders

A. Angela – Evaporation Pond (Alex, Danny)
B. Will – Deep Well (Mitchell, James)
C. Ray – Brine Collector (Sahar, Woo)
D. Ross – Emerging Technologies (Katie)
E. Alex – Physical Team (Angela, Woo)
F. James – Regulatory Team (Danny)
G. Sahar – Technological Team (Ray, Katie)
H. Mitchell – Financial Team (Ross)
I. Ross – Poster Team (Mitchell, Alex, Angela, Woo, Will)
J. Sahar – Brochure Team (Ray, Katie, Danny, James)

Research Sub-Team's Responsibilities:

A. Research how zero liquid discharge technologies work
B. Research startup and operating cost
C. Research land usage, environmental effects, and any other pertinent information regarding the possible technologies to achieve zero liquid discharge.

Extensive Research Team's Responsibilities

1. Physical Team will check the availability of water, the availability of discharge points, the availability of space, and the quality of source water. Physical Teams responsibilities correspond to the power plant's location and available resources including coal.
2. Regulatory Team will make sure all of our objectives are within the state's regulations. Including the NPDES, groundwater protection, air emissions, and waste disposal. Will work closely with Technological Team to make sure our work is within code.
3. Technological Team will take care of the materials of construction, limits of the equipment, recalcitrant constituents, and reuse and recycling water quality constraints. They will take care of the water balance requirement. Will work closely with Physical Team.
4. Financial Team will research all money issues such as capital cost, O&M cost, and opportunity costs. Will also have to research costs of alternative technologies and compare to show why the one we chose is better.

Poster Sub-Team Responsibilities:

- Design our presentation poster to requirements with our researched information.

Brochure Sub-Team Responsibilities:

- Design our presentation brochure to requirements with our researched information.

10. Designation of Roles

A. Meeting roles:
   - **Minute Taker**: Angela Ng
   - **Agenda Maker**: Will Pattermann, agendas will not be written but instead will be announced before each team meeting.
   - **Time Keeper**: Will Pattermann

B. Status Roles:
   - **Weekly Timesheet Collector/Summarizer**: None. As a group we decided that we will each do our part of the project to accomplish our tasks. Individually, we will fill out the timesheet on iGroups.
   - **Master Schedule Maker**: Will Pattermann
   - **iGroups**: Alex Ong