ILLINOIS INSTITUTE OF TECHNOLOGY

IPRO 302
AMPS - Alternative Metropolitan Power Strategy

Project Plan
Spring, 2010

Sponsored By: Sargent & Lundy

Abstract

IPRO 302 has been established to come up with a hypothetical design that will account for 20% of the City of Chicago's power needs using renewable sources such as photovoltaic solar, solar thermal, and wind turbines. The system will be secured by using combustion turbines when the environmental conditions are not met in order to run the renewable sources.

The team has established itself as AMPS – Alternative Metropolitan Power Strategy, and is being sponsored by Sargent & Lundy, one of the industries leading power consultation companies. They have provided the group with very specific guidelines, and expect a final proposal meeting all requirements. At the end of the project, the team is expected to give a formal presentation of results to both Sargent & Lundy and IPRO judges during IPRO day.

The team will go through three basic phases of preliminary research, extensive research and design synthesis, and well as create the presentations and deliverables. In the preliminary research phase, information on environmental and power consumption for the city will be found. Additionally, case studies of existing wind, solar and CT farms will be reviewed in order to determine the cost of operation for these facilities. Moving on to the design synthesis phase, the information collected will be compiled and a design will be proposed using the most economical means. After the design is created, the presentation and report phase will begin, resulting in a deliverable proposal that will meet the needs of Sargent & Lundy, as well as the IPRO committees.

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Team Information

AMPS – Alternative Metropolitan Power Strategy

Second Power for The Second City

Project Purpose & Objectives

The objective of this project is to identify and evaluate renewable energy technologies that will support 20% of the electricity demands for the City of Chicago. To accomplish this mission, we will:

1. Analyze the electrical requirements for the City of Chicago and assume a hypothetical legislated renewable portfolio standard (RPS) of 20% must be met. This RPS, which is being considered on the Federal level and is law in the State of California, would require that 20% of the power sold into the market must be produced by renewable energy power sources.
    a. Evaluate the electrical requirements on an hourly, daily, and yearly basis to fully understand the system load profile.
    b. Evaluate wind and sun conditions in state of Illinois on an hourly, daily and yearly basis to determine how well it matches the demand profile.
2. Analyze performance of commercial wind turbines (data available on websites) and how they will perform according to your wind analysis.
    a. Calculate how many turbines will be required to meet full load and supply backup power sources as necessary to fully support the demand profile.
3. Analyze and select back up power sources to economically support the system.
4. Estimate distribution of wind turbines and/or solar facilities.
5. Estimate transmission distances from source of power to end user in the city.
6. Estimate power losses due to transmission and distribution systems.
7. Include sufficient renewable capacity of wind turbines and/or solar panels to support power requirements of back up source and transmission losses.
8. Calculate total renewable system cost estimate for wind turbines and solar systems, back up power source, land requirements, maintenance roads and transmission lines to City of Chicago.
9. Calculate $/kWh of production and compare with today's current coal-based power rate. Additionally, consider the cost of CO2 emissions and look into its impacts on the future cost of coal-based power.

S&L is interested in all items listed above and the results from the analysis

Team Objectives

1. Collect information and results throughout the project and organize into a format that may be easily transferred from the 1st semester to 2nd semester of the IPRO
2. Engage all members of the team in their areas of interest.
3. Present results from analysis to S&L
4. Communicate and coordinate between sub-teams to meet goals effectively.

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 ask for help or 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.
- When confrontations arise, they shall be handled appropriately by the sub-team leader, then team leader, then adviser, and in that order.
- To work cohesively and produce a quality product

Background

Project Background

Interprofessional Projects at IIT have been offered for the past decade. They are team-based courses that consist of students from different majors. IPRO provides students with a chance to apply the knowledge that they have gained in the classroom by working on solutions for real world problems. All IIT undergraduate students are required to complete at least two IPROs in order to graduate.

Sponsor Background

Providing complete consulting, engineering, and project development services for all types of fossil-fuel, nuclear, and renewable power generation, Sargent & Lundy has established itself as a leader and innovator in the electric power industry and related businesses since 1891. From their first assignment pioneering the design of the Harrison Street Station for Chicago Edison Co. in 1892, to their new 790-MW supercritical station in Iowa, the first plant in the U.S. to use advanced supercritical technology, S&L continues to be at the leading edge of innovation. Their record of accomplishment includes the design of 884 power plants totaling 122,149 MW, and more than 5,000 circuit miles of high-voltage and extra-high-voltage transmission line with more than 100 substations.

Sargent & Lundy serves their clients progressively by placing emphasis on in-depth services for operating power facilities, and by helping shape clients' plans for the future of their power business assets. Operations and maintenance support services assist clients by providing consulting services such as due diligence reviews and condition assessments, improving performance, meeting regulatory compliance issues, and improving the bottom line.

Based in Chicago, Sargent & Lundy has a global presence with project teams on every continent. ISO 9001:2008 certified compliance with SL-QAP and SOPs is mandatory for all work across the company. Approved by the United States Nuclear Regulatory Commission, Sargent & Lundy's compliance with their nuclear quality assurance program, SL-TR-1A, is also required. [1]

Technology Background

Power demands are currently met through a combination of nuclear, fossil fuel, and natural gas based generation. Nuclear power generates most of the baseline power, the minimum power needed on a daily basis, because it produces the cheapest energy after initial construction costs have been met. The amount of nuclear generation also can't be changed easily, making it the perfect candidate for baseline power. Fossil fuel plants generate the balance of the needed baseline power, and more plants turn on as the day starts goes on to meet increasing demand. Natural gas generation, or combustion turbines (CT), is used to meet peak

[1] Most of the Sponsor Background was provided by the Sargent & Lundy website.

demands because the generators can turn on quickly. This IPRO is going to look at three types of renewable power generation in order to replace 20% of the standard generation profile.

Solar Thermal energy is a technology that harnesses the heat from sunlight to generate electricity. Low and medium temperatures can't be used to efficiently convert the heat to electricity, so the sunlight is concentrated using mirrors to bring the temperature to 350-700°C. The heat is generally converted into electricity by making steam and using a conventional turbine generator. One benefit of solar thermal energy over photovoltaic solar energy (described below) is that heat can be stored more efficiently than electricity can. Solar thermal plants have the option of storing heat during sunlight hours and using that heat later to generate electricity during overcast days or nighttime hours.

Photovoltaic solar energy is a technology that uses the photons from light to excite electrons in a semiconductor (almost always silicon). There is one positively charged layer and one negatively charged layer of semiconductors in a PV cell, and when exposed to light a voltage is created between the two. Unlike solar thermal energy collectors, increasing the heat of the solar cells decreases the efficiency; any temperature above room temperature generally reduces the performance of PV cells.

Wind energy is produced by taking the kinetic energy if the wind and using it to turn a turbine to generate electricity.

One of the largest problems with alternative energy is that it is non-dispatchable, meaning that power is only available when the wind is blowing or there is sun, and not easily predictable for short term operation. Since the power generated by plants has to match the power demand at the current time, large amounts of alternative power can cause instability in the power grid.

Ethical Considerations

During any project, certain ethical considerations need to be addressed. For the project, it is important that the team as a collective whole maintains a high standard of integrity and cite all sources used during the research and design stages. Prior work must be cited and credit given to the original authors.

Internal ethical concerns come about with honesty and accountability. Each team member is responsible for producing quality material that is not offensive and contributes to the greater good of the team. Additionally, slanderous or hurtful comments or actions towards other team members will not be tolerated.

The team should also make sure that external concerns are met, and that at no point should the team attempt to hurt other IPROs or damage the reputation of any group or individual.

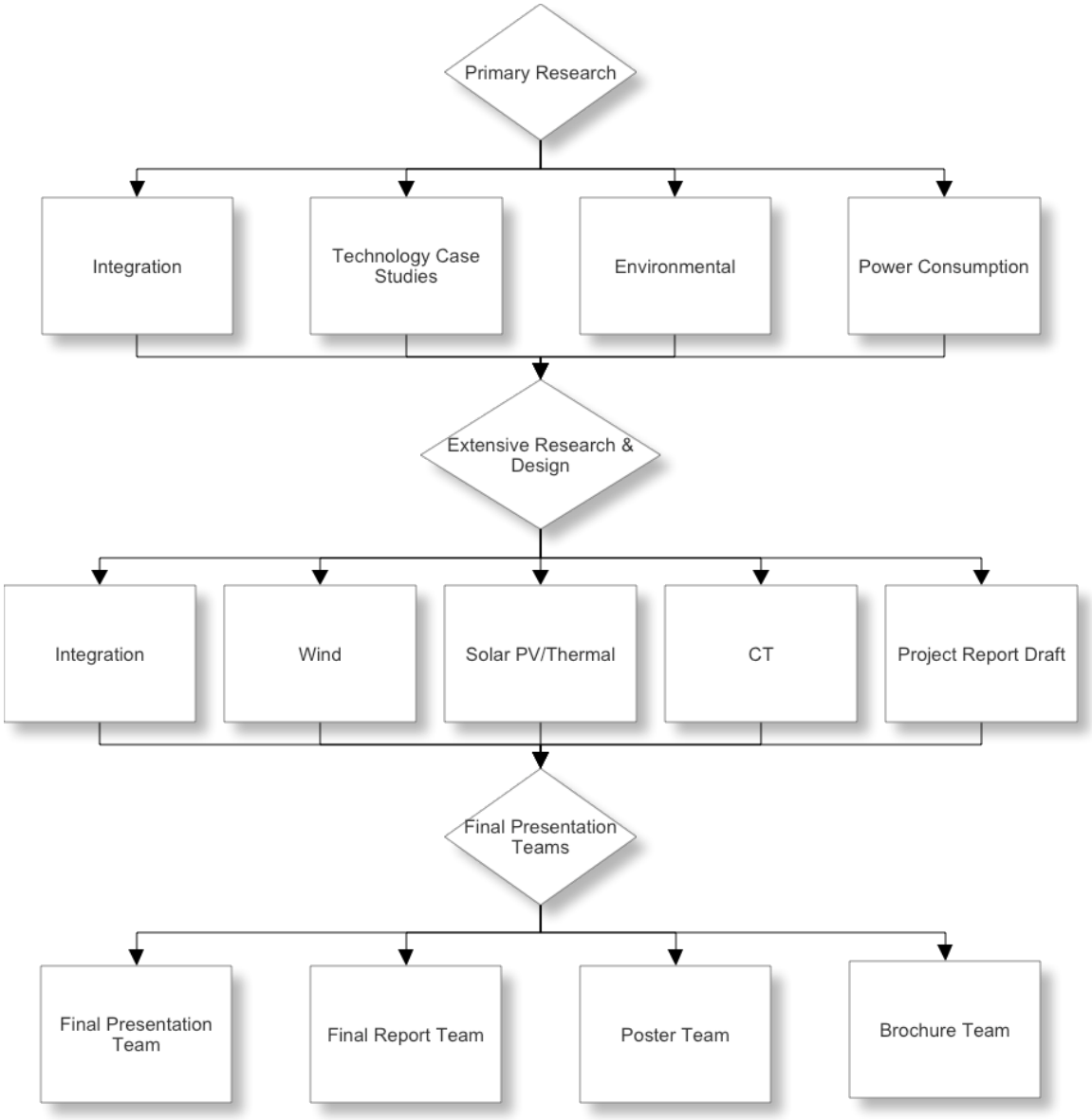
Work Breakdown Structure

Major Tasks

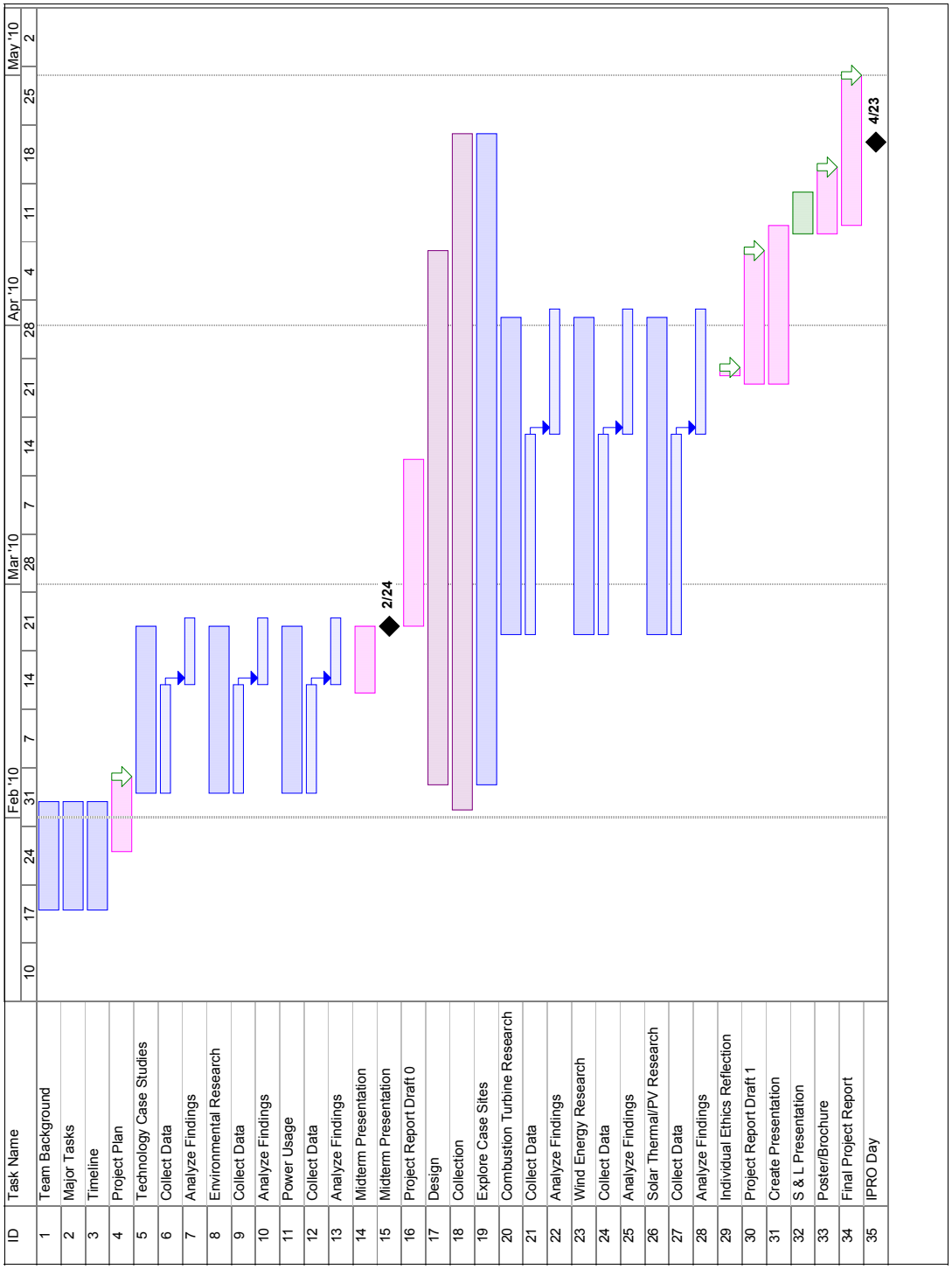
In order to achieve our expected results, the project will require the completion of many tasks to lead to our final resolution. First, we must analyze and determine the electrical requirements for the City of Chicago; then define the 20% of this demand to meet for the renewable portfolio standard. This will require evaluation of electrical demand on an hourly, daily, and yearly basis to completely understand the load profiles. Similarly we must evaluate the solar and wind conditions on an hourly, daily, and yearly basis to accurately determine how well climate conditions will provide sources of energy production given our load profiles.

We will also need to calculate and analyze the performance and distribution of wind turbines, solar PV cells and solar thermal plants, and combustion turbine backup supply systems. Next, we will estimate transmission distances from power sources to end users and the associated power losses due to this transmission distance. To analyze the economics of our system we will calculate the total system costs, including costs of wind turbines, solar production systems, back-up combustion turbines, land requirements, maintenance, transmission lines and methods, etc. Our final major task will be to calculate the $/kWh of our system's power production and compare with current rates. We may also evaluate the reduced carbon dioxide emissions against today's current rates.

Team Structure



Timeline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Task Name
Feb '10
Mar '10
Apr '10
May '10
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24
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32 S & L Presentation
33 Poster/Brochure
34 Final Project Report
35 IPRO Day
2/24
4/23

Expected Results

By the end of the semester our aim is to develop a hypothetical model that replaces Chicago's 100% non-renewable energy consumption to 80% non-renewable and 20% renewable. Our end product would be a presentation and report explaining our evaluation. We will present our work at IPRO day to an audience experienced and interested in the energy sector. Wind and solar power will be our major focus in the renewable energy, with combustion turbines being backup systems. The model would specify the percentage of wind and percentage of solar contributions, location, and technology, along with all of our assumptions. We also intend to find the $/kWh of the production and compare it with today's rate.

Phase	
Research	Data collected necessary for the project
Analysis	Data would be analyzed and interpreted. Assumptions would be defined
Pre-Design and Design	An interpretable working model meeting our goals
Presentation	Presenting all deliverables

To achieve our goal we might visit power plants, wind Farms, solar fields, and local power companies for firsthand knowledge and collection of data. The technological knowhow will be acquired from different case studies and publications that may be found on the Internet or in journals.

A study of this sort will have its set of challenges. As data collection is an important phase in our project, finding legitimate and verifiable sources is a challenge. This is a two semester IPRO and documenting and passing on our research to the next team is very important aspect to it. We plan to designate a group specifically to document and sort data. Another problem we might face will be communicating within the various sub-teams and coordinating events. Managing time efficiently and adhering to the Gantt chart are also important issues.

Project Budget

IPRO 302: Chicago Electric Grid

Item	Description	Cost
Office Supplies		
Printing	Weekly Agendas	$20.00
CD's	Presentation CD's, Data exchange to next group	$10.00
Travel Expenses		
Wind Farm Visit	$0.55/mile x 272 miles x 3 cars	$450.00
Data Access		
Journals & Publications	Research Activities	$100.00
Webinar Registration	Research Activities	$100.00
Website Expenses		
Domain Registration	1 Year Registration	$10.00
Hosting	Off-site hosting of database and website	$20.00
Demonstrations		
Wind Turbine	Demonstration Turbine	$500.00
Solar Panel	2 Demonstration Solar Panels (PV & Thermal)	$150.00
	Total:	**$1,360.00**

Team Roles

Agenda Maker: Ray Ballard

An agenda is an important meeting tool that increases efficiency and is essential to outlining a plan to accomplish the team's meeting objective(s). The Agenda Maker makes such a plan and distributes copies to team members to ensure everyone knows the purpose of the meeting, and the outline to accomplish the goal.

Time Keeper: Sarah Crites

The Time Keeper tracks the progress of the meeting against the agenda outline and encourages the team leader to keep the meeting going.

Minute Taker: Sarah Crites

An important meeting tool that confirms what happened at a meeting for absent members, as well as restates any decisions that were made. The Minute Taker will post outlined minutes in iGroups.

Transition Manager: Brent Frey

In a continuing IPRO, it is critical that all decisions, collected data, assumptions, discoveries, complications, and other events are tabulated and placed in an easily understood format for the next semester of the IPRO. Without such a manager for the team, it is possible that the next IPRO team would be confused, miss information, or make incorrect conclusions about the previous team's decisions. The Transition Manager will play an important role in formulating the project report, as well as collecting other information/assumptions for the transition documents.

iGroups Moderator: Urszula Zajkowska

The iGroups Moderator will keep track of timesheet status for members and ensure that all files, emails, photos, and other documents are properly organized.

Yagoob Alsharief

4th Year EE	*773.629.2209*	*yalshar1@iit.edu*

Individual Strengths to Contribute: I have taken some classes in power system analysis. Also, I have some experience with some computer software that are used in analyzing power systems, such as, Power world and PSS/E.

New Knowledge/Skills to Develop: I aim to improve my research skills while working on one of the challenging problems in real world. Beside that, I want to improve my skills in working within a team.

Overall Expectations About the Project: working on this project will provide us with a chance to understand some of the cutting edge technologies in power generating. I hope all the team members will find ways to contribute to the project and benefit from it as well regardless of their majors

Ray Ballard

4th Year ChE	*312.519.8930*	*rayballard@gmail.com*

Individual Strengths to Contribute: Communication, Organization, Leadership, Team Development, Understanding the Needs and Characteristics of the Group, Chemical Engineering background

New Knowledge/Skills to Develop: Use leadership skills on a technical project, and when called upon, communicate chemical engineering expertise to people of different backgrounds.

Overall Expectations About the Project: Good group cohesion, enthusiasm, and interest in completing the large number of difficult tasks. We have a good team that can do just that.

Sarah Crites

4th Year EE	*210.259.6350*	*scrites@iit.edu*

Individual Strengths to Contribute: Individual Strengths to Contribute: Some knowledge of power systems; experience helping coordinate/communicate IPRO team activities; organized; willing to do whatever jobs need to be done to complete the project

New Knowledge/Skills to Develop: I'm looking forward to learning more about the field of power engineering, especially the future of renewable energy; I hope to improve my real-world problem solving skills; and I want to get good non-classwork experience that will help me after college.

Overall Expectations About the Project: I think that, working on this project, we'll all end up learning a lot about power systems in general and wind and solar power specifically. I think it will be a good opportunity to tackle real-world power transmission problems, and to learn about the business/economics side of projects like this.

Daniel Drecoll

5th Year ARCH	*630.781.2750*	*ddrecoll@iit.edu*

Individual Strengths to Contribute: My experience at IIT in the College of Architecture have included much study, research, and design with sustainable technologies and practices. Specifically in the

area of redesigning the Chicago electric grid and production systems. My training here has also taught me how to approach problems from all angles and integrate many ideas into one cohesive solution.

New Knowledge/Skills to Develop: Team work and leadership are skills I hope to develope further through this project. I'm very interested in further developing my knowledge of Chicago and Illinois electrical systems, production, and distribution and how we can change them for the better.

Overall Expectations About the Project: I expect that we will develop an accurate and well designed project that achieves our electrical needs and defines all criteria that was necessary to prove the real time success of undertaking this project in the field.

Brent Frey

4th Year CPE *847.508.4776* *brentfrey@iit.edu*

Individual Strengths to Contribute: My leadership skills and my ability to identify areas that need improvement, combined with my knowledge of power systems should allow me to help the team to achieve our ultimate goal.

New Knowledge/Skills to Develop: I want to learn more about large-scale power systems, as well as refine my skills in business analysis and the ability to model a complex system. I would like to learn more about researching an idea based of existing case studies, and I feel that this IPRO will require heavy research.

Overall Expectations About the Project: To work with Sargent & Lundy to meet the demands of the project and advance my skills.

Akshay Goliya

3rd Year EE *312.513.4908* *agoliya@iit.edu*

Individual Strengths to Contribute: Desire to work in a team. I am currently majoring in Electrical Engineering, so have significant knowledge to relate to the technical side project.

New Knowledge/Skills to Develop: I am eager to explore the data collection and analysis process for this project. Communication and team dynamics are also an important set of skills I would like to work on.

Overall Expectations About the Project: Power is one of the most growing sectors of today and as we speculate a major change in the generation methodology this project is very relevant. I am excited to deal with this real-world problem with a lot of enthusiasm. I expect to use my knowledge and am open to learning any new skill required for the project.

Allen Klug

4th Year EE *630.908.8077* *aklug@iit.edu*

Individual Strengths to Contribute: Good with numbers/computations. Methodical

New Knowledge/Skills to Develop: Ability to convey ideas and data pertaining to power systems to people that are not EE majors.

Overall Expectations About the Project: I hope to learn more about how power systems and the electric grid work.

Ray Marshall

3rd Year CAE *773.656.3072* *rmarsha2@iit.edu*

Individual Strengths to Contribute: Some of my individual strengths to contribute to the team are that I'm good when it comes to researching topics, graph design, and good problem solving skills.

New Knowledge/Skills to Develop: The new knowledge I would like to take from this is a better understanding about using sustainable materials in things I design. As, far as for skills to develop; I hope to improve on trusting others when it come completing an assignment.

Overall Expectations About the Project: Overall I expect to work in a team environment and gain more knowledge about different sustainable resources.

Hee-Jong Min

2nd Year BUS	*773.459.1053*	*hmin2@iit.edu*

Individual Strengths to Contribute: My major is Business Administration, especially specializing in Finance. So I want to help and contribute to my team by analyzing the business data and cost. Our team objective is to find the appropriate method and location to supply the renewable energy as well as to match these method and solution into feasible business accompishiment, in addition to real business environment. So I want to analyze and approach to the business solution.

New Knowledge/Skills to Develop: My major is Business Administration, especially specializing in Finance. So I want to help and contribute to my team by analyzing the business data and cost. Our team objective is to find the appropriate method and location to supply the renewable energy as well as to match these method and solution into feasible business accompishiment, in addition to real business environment. So I want to analyze and approach to the business solution.

Overall Expectations About the Project: first of all, the most important thing is to have active communication with each other. of course, it should be grounded by the successful research and invastigation. I hope that our team will be initiative and active and helpful to all team member.

Li Qiu

4th Year EE	*312.925.1722*	*lqiu3@iit.edu*

Individual Strengths to Contribute: Love of learning is one of the reasons why I come to university. In this IPRO, we have students with varieties of major and come from different backgrounds. Our project, the renewable energy, is new to most of us. So the passion of learning will be the main driving force for us to achieve our project goal. Also, fairness is another virtue that I like to contribute to this IPRO class. Every team member in this project should have equal amount of privilege to contribute their works and to share the result.

New Knowledge/Skills to Develop: My main goal for this IPRO is to learn more about the renewable energy status in the United States. I also want to gain more of term work experiences.

Overall Expectations About the Project: We can have preliminary knowledge of renewable energy in the Chicago area and the State of Illinois.

Michael Sullins

4th Year PSYC	*815.685.5540*	*msullins@iit.edu*

Individual Strengths to Contribute: Motivated and hardworking.

New Knowledge/Skills to Develop: Working with a team.

Overall Expectations About the Project: Learn new things while successfully completing our tasks.

Urszula Zajkowska

4th Year ChE *312.730.3128* *uzajkows@iit.edu*

Individual Strengths to Contribute: I can work in the group environment as well as individual. I am open to new ideas and I am very creative when it comes to finding solutions. I am good with meeting the deadlines and I am very dedicated to the projects I work on.

New Knowledge/Skills to Develop: I hope to have better understanding of the challenges that need to be faced when it comes to applying renewable energy sources. I hope to improve my analytical skills and ability to work with people with different educational background.

Overall Expectations About the Project: I hope the members of the group will be able to use their strengths and come up with a great solutions of the project. Also, I hope the sponsors will be satisfied with our results.