Renewable Energies Capstone Team
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APS and SEDI Sponsors
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Dear APS and SEDI Sponsors:

The Renewable Energy Capstone Team is proud to present our project proposal for the evaluation of implementing renewable energy in Coconino County. We appreciate you (APS and SEDI) selecting us for this project. We will not disappoint.

The basic problem is that renewable energy currently costs more than fossil fuel energy according to a simple dollar to dollar comparison. We believe however, that renewable energy sources will pay off in the long run and that they also have a number of intangible benefits for Coconino County. The scope of our project is to first put dollar values on the tangible and intangible costs and benefits of renewable energy options and compare with clean coal.

We commit to completing this analysis by May 2, 2008. We will deliver a breakdown of the direct cost of wind, solar, and clean coal as our base argument. We will then deliver a summary of each tangible and intangible benefit provided by the renewable energies and clean coal. Finally, we will deliver a breakdown of the overall cost that includes any offsets from intangible benefits.

The team would also want to invite our sponsors from both APS and CCSEDI to our final capstone presentation on April 18 at the du Bois center at NAU, more details of the schedule and map will be communicated later to you through email and our website by April, 2008.

After our last meeting, the team made changes as to how the project will be tackled. The number of renewable resources that we are analyzing now is only two: wind and solar, however we have added clean coal to the list since that is the most likely alternative. Biomass will not be analyzed any further. It's not a very likely technology because of the difficulty in obtaining long term stewardship permits from the forest service, which makes employing a long range business plan impossible. Without a guaranteed fuel source no one will invest in Biomass. The team likes to request that Dreamweaver be purchased by the sponsors so website updates are possible.

As of now, we have made progress in analyzing wind, solar and clean coal. Analysis for wind has been made with a 60MW plant but we still have to do that for 120MW and 500MW. With solar and clean

coal, the team is still working on the 60MW analysis. We are still on track and we are focused and working hard. More details are provided in the report.

The result of this project will be that as our customer, you will be armed with concrete information with which to sell the idea of renewable energy power production to the people of this county. Even with renewable powers' initially higher cost, we hope the benefits would be so great that the customers of electricity would purchase it anyway.

To ensure a timely start and completion of this project we request that you, the client, look over our status report and indicate your acceptance or rejection by no later than March 10th, 2008. By signing the acceptance letter on the last page, you agree to our report and authorize us to proceed with our project as outlined in the body of this report.

Sincerely,

Renewable Energies Capstone Team

Harnessing Renewable Power Generation within Coconino County

A Qualitative and Quantitative Cost Benefit Analysis

Mindy J. Dyar

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Capstone Project Proposal

Team Contact Information

Renewable Energies Capstone:

Students will do a qualitative and quantitative cost benefit analysis of sitting renewable generation within Coconino County.

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Table of Contents

1.0 Executive Summary

This report contains our proposed design approach for the cost benefit analysis of harnessing renewable power generation in Coconino County, AZ. The renewable resources that are analyzed are wind and solar which are compared to clean coal, our base argument. These two have been proven to have potential here in the county so our analysis will focus on possible benefits that these two energy resources could bring to the community that clean coal would not be able to.

The first item presented is our problem statement. This is an overview of what we believe the problem we are addressing is. This section also contains a system diagram. Next are our updated research survey and requirements and specifications. The research survey contains the most recent and correct information regarding research about the renewable resources we are interested in, such as wind, solar, and clean coal. The requirements and specifications section contains all items which we must include in our analysis. This section was also updated to include recommendations from you.

Following the research survey is our proposed design approach. We are doing a quantitative and qualitative cost benefit analysis, so it is very important that we consider all tangible and intangible benefits regarding renewable energy production here in the county. The design section explains how we will go about executing the analysis such that we meet the requirements of the project. This section also contains our rejected approach, materials needed, and constraints.

Next, the budget section follows the design section. The budget section contains a list of materials we need for the project. Also, information regarding what materials will be supplied by us, NAU, and the sponsor will be specified. The last item in the budget section contains information on payment arrangements and reimbursement.

The last item contained in this report is a schedule for the proposed project. All known deliverables are listed with due dates. Finally, the last item included in the report is an acceptance document. Upon full agreement concerning the plans for doing this project, both parties will sign this document.

2.0 Problem Overview

This section contains the problem statement and system diagram. Without defining the problem at hand, we would not be successful in crafting a successful cost benefit analysis. Presented below is a detailed description of the problem to be solved. The statement has been revised to include all suggestions made by our sponsors and advisors. The system diagram shows the flow of our analysis project.

2.1 Problem Statement

Arizona Public Services (APS) and Coconino County Sustainable Economic Development Initiative (SEDI) in collaboration with EE senior students from NAU will, in the fields of renewable energy and sustainable economic development, research and conclude on a renewable resource best suited for Coconino County and determine if such a project would be feasible in terms of social, economic, and environmental factors.

The team is to do a cost benefit analysis of renewable energy resources already in use. The renewable resources that will be researched are wind, and solar. Research materials to evaluate the different types of energy amounts produced in Northern Arizona will be provided by SEDI. The cost benefit analysis will focus on wind and solar. The reason for narrowing down the possibilities to two resources is to increase the focus and in depth analysis.

The analysis will take into consideration tangible and intangible factors that could impact a renewable energy plant here in Coconino County. The intangible factors could include any environmental impacts the plant would have on the community e.g. reduced CO_2 emissions and water savings while, the tangible factors would include the premiums and actual costs of the construction and maintenance of a power plant in the Coconino County community. The team would learn and quantify the non-tangible factors and add them to the already provided data on the tangible factors to provide a more feasible and environmentally healthy renewable resource.

The renewable resource decided upon at the end of the research stage should be economically feasible and environmentally friendly. Our choice should also be financially beneficial for Coconino County. Since some of the power generated will be exported out of the county, the renewable power plant should be sized to be able to do so. The team will be using scaling (either linear or quadratic), the models provided and the quantified non-tangibles to come up with their final quantities.

2.2 System Diagram

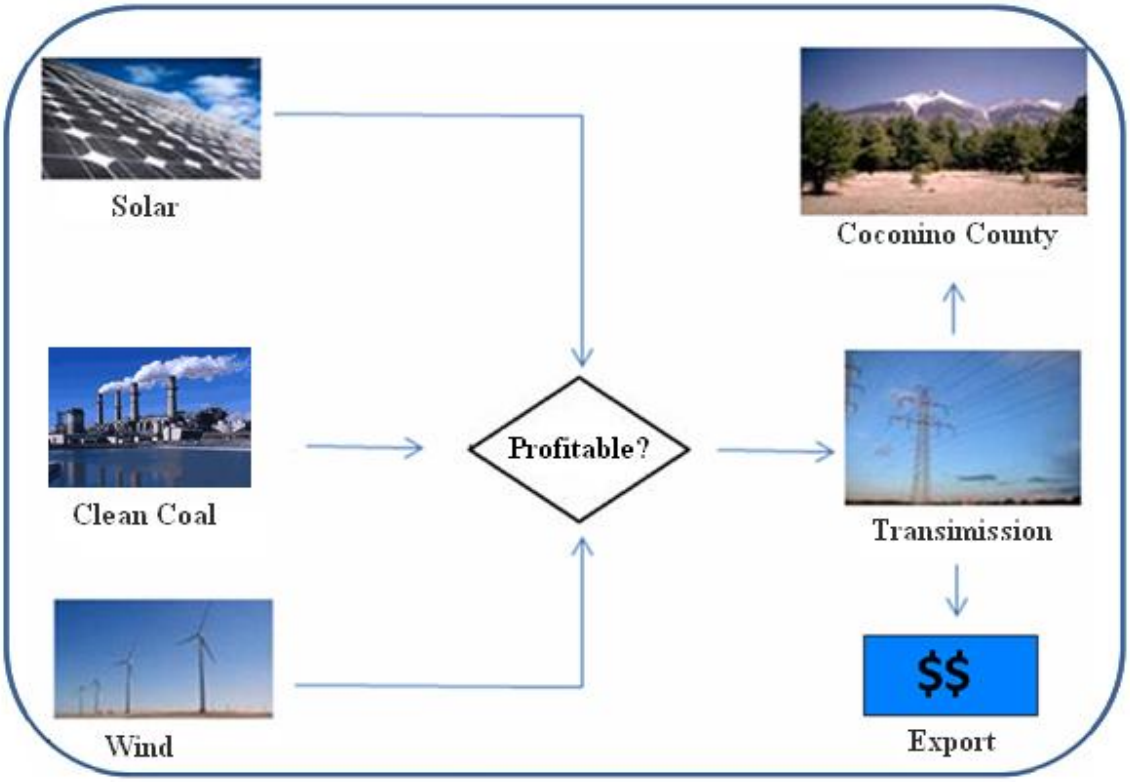


Figure 1 – Diagrammatic Representation of Project

3.0 Research Overview

This section contains our research survey and our requirements and specifications for the project. The research survey is a summary of the types of technologies that we will analyze in the project. Solar, wind, and biomass technologies and their current costs are discussed in the survey. The requirements and specifications outline what we must consider in doing the analysis. Areas such as mechanical, economic, environmental, social, documentation, testing, and general all have specific requirements and specifications.

3.1 Research Survey

So far, we've been researching about wind and solar plants. We will not be considering geothermal, biomass or hydro because the resources are not feasible in Coconino County at this time.

Solar

Solar electricity is generated with five main technologies: Trough-Electric, Stirling, Power Tower, photovoltaic and Compact Linear Fresnel Reflector. A trough electric plant is a grid of individual trough-like mirrors that focus their light onto receiver tubes carrying oil. The oil is heated and is harnessed to turn a turbine. The next type of solar plant is a dish or Stirling system. This system is interesting because the dish tracks the sun. It focuses all the light to a specific point. Photovoltaic converts sunlight directly into electricity. CLFR is similar to a trough, but smaller and uses fewer moving parts.

The heat 'runs' a Stirling generator to create power. The last commonly used solar system is the power tower. The power tower consists of a tower called the collector, and a field of mirrors reflects the sun's light onto the collector which heats up a tank full of salt fluid. This salt fluid reaches extreme temperatures and the heat is used in turning a turbine.

Solar power is still very expensive when compared to existing fossil technologies. It is very clean, but must rely on the absence of cloud cover for best performance. A solar plant to generate significant power requires a considerable amount of land area. The biggest obstacle is the end cost per kilowatt-hour to the customer, which could range from 20 – 25 cents per kWh (compared to 11 cents per kWh for fossils).

Wind

Wind is by far the most simple to build and maintain. Wind farms use windmills to generate electricity. Blade technology is becoming very efficient and wind power is found across the world. The overall cost of wind power is almost competitive with existing fossil technologies. The downside of wind is that it needs be built where it is windy most of the time. However, Coconino County is only average in terms of how much wind actually blows versus not. Wind is very clean and requires the same or less space than a solar plant.

Benefits

Renewable energy could benefit Coconino County in various ways. First of all, the environmental benefits are large. Annual savings on water and less air pollution will be among the benefits that are recognized most. Additionally, new jobs, taxes, and revenues will be created. With the higher costs of renewable energy now, the benefits need to be quantified to show that once savings in areas like public health and air quality are accounted for, renewable energy is really beneficial to implement within the county.

3.2 Requirements and Specifications

1. Mechanical

   Different wind technologies will be compared. Things that will be looked at are blades, size, shape and output. Different solar technologies will be studied as well. The things that will be looked at are different types of plants, size, and efficiency of cells.

2. Economic
   I. New property taxes
   II. New revenues to private and public landowners, plus multiplier benefits
   III. New jobs will be created for the Coconino County
   IV. Economic Development – attraction factor for new manufacturing and service jobs
   V. Multiplier effect of ratepayer dollars staying in-state vs. sending our utility fees to other states when we import energy
   VI. Stable priced energy (wind, solar), not subject to fuel price volatility and increases

3. Environmental
    I. Zero (wind, solar) emissions from the plant
    II. Improved air quality in the Coconino County compared to fossils
    III. Zero or minimal water consumption for energy generation compared to thermal generation
    IV. Watershed preservation
    V. Prevent habitat fragmentation (alternative to subdividing large ranches)
    VI. Needs to be able to operate in cold weather

4. Social
    I. Public health benefits (no toxic air emissions contributing to asthma and other public health issues)
    II. Economic diversification for land owners
        a. Provide alternative to subdividing
        b. Provide new revenues to augment traditional agricultural economics (ranching, farming)
        c. Help preserve rural way of life and ranching/farming viability
    III. Compatible land use
        a. Renewable energy generation is compatible with ranching, farming, and public land uses
    IV. Domestic energy source
        a. Reduce dependence on foreign energy sources

5. Documentation
    I. Our documentation must consist of all research, tables and models used in determining the best renewable energy source.
        a. We must disclose all sources of information for this project.
        b. We must include all parameters we used in a software model.
        c. We must disclose which software models we used.
6. Testing

I. The only testing we will need to do is with software models of the specific renewable energy sources. We must exhaustively simulate multiple implementations of biomass, solar and wind energy.

II. The final results will also include the cost per kWh that the customer will be paying, and it should be competitive to the other existing resources.

7. General

I. Our client would prefer to build one large plant of a single type of renewable energy. The end cost to the user must not be significantly higher than existing fossil sources

a. The cost to the end user will be higher initially, but must not be so high as to double or triple a user's utility bills.

End users must understand that renewable energy will become cheaper in the long term, when costs of fossil fuels escalate in the next 10 – 20 years.

4.0 Design Section

This section contains our chosen design approach, rejected design approach, analysis and simulations, materials needed, and constraints. The design approach section describes how we will go about doing our research analysis. The rejected approach section discusses the reasons for the exclusion of the renewable technologies that are not being studied. Analysis and simulations sections explain the method we will use in simulating models for our analysis. A list of the materials that will be needed for the project is also contained in this section. Last in this section, the constraints of our project are discussed.

4.1 Chosen Design Approach

The APS renewable project is one that involves the cost benefit analysis of renewable power plants in the Coconino County. The renewable projects we considered were mainly: solar, wind, hydroelectricity, geothermal and biomass. However, three of the five: geothermal, hydro and biomass were nullified. Geothermal and hydro were nullified because they weren't feasible in Coconino County even though they could have been profitable. Biomass was also nullified due to the difficulty in obtaining long term stewardship permits from the forest service. This makes employing a long range business plan impossible and without a guaranteed fuel source no one would invest in Biomass.

The remaining two technologies, solar and wind will be considered as alternatives to clean coal in the cost benefit analysis. The county has a huge amount of sunshine so an implementation of solar in the county is feasible. The county gets enough wind and may be the most feasible now. The project goal was to provide a cost benefit analysis of the tangible and intangible factors that would go into a renewable power plant. The tangible factors are the premiums and actual costs of production and maintenance, while the intangible factors involve the cost of the externalities. Intangible factors could include the increase of health problems and cost for people nearby due to increased levels of air, land, and water pollution.

The team would be supplied materials for the analysis mainly by the client, which would also include already quantified tangible factors and some software models. The team would then quantify the intangible factors and add them into the general equation for the economic benefits of the entire power plant. The premium that the people would be paying would then reflect all the factors involved. Ultimately, what will be determined is if renewable prices are competitive enough compared to the existing fossil fuel prices when all the benefits are considered.

We will attempt to quantify the intangible factors by comparison. For example, concerning air pollution, we will compare the air quality of a city containing a clean coal power plant to the air quality of a remote area of Northern Arizona to determine a base case. Next, we would look at emissions data from renewable plants and conclude if the renewable plant would lessen air pollution. Another aspect of analyzing how a renewable plant would impact air pollution would be looking at the number of people hospitalized due to air quality issues in or near cities with coal-fired power plants. We will compare this to cities of similar industry and size that house renewable energy plants to determine if there is a decrease in the number of hospitalizations from the lack of air quality.

4.2 Rejected Design Approaches

In the initial consideration of renewable power generation, two types of renewable energy technologies were immediately dismissed, geothermal and hydro. Biomass was dismissed from the project much later than geothermal and hydro. Since wind and solar are more likely to be implemented, we will focus our studies on those two renewable energy technologies.

Geothermal was not considered because the county does not have an area where the magma is close to the crust. For geothermal to work, there has to be access to the Earth's magma. Pipes with liquid are laid from the surface to the magma to generate steam to run the turbines. Even though you could build pipes to connect to the Earth's magma, the expenses involved are so high that your profits would not compensate your expenditure for a very long time. It could also involve a lot of costly trial and error to obtain such a point if the magma is not that close to the crust.

Hydro was also taken out of the picture because the county has a very limited supply of water. The main source of water in the county, to be precise, is Lake Mary, which has a really inconsistent flow every year. It's had really poor amounts of water for the past five years since the county has experienced less precipitation. Hydro would not work if the droughts continue to happen. It would be ridiculous to invest in hydropower here in Arizona because it's the desert.

Biomass is in abundance in the county. As a matter of fact, Northern Arizona has the highest supply of biomass in the whole nation. However due to harvesting difficulties, primarily from the fact that motorized vehicles aren't allowed in areas with high supplies of biomass, this approach has been excluded from this analysis. Additionally, Northern Arizona isn't the best choice for biomass crops due to the high elevation and cold winters.

Shown in Table 1 is a table of our initial research analysis. We listed each possible renewable energy source and researched their potential in Coconino County. In our initial analysis, we decided if the resources were feasible and profitable, and from those results, we concluded that we would do research on wind, and solar.

Resources	Initial Analysis		Conclusion
	Feasible	Profitable	
Solar	Yes	Yes	Analyze
Wind	Yes	Yes	Analyze
Biomass	No	Yes	Ignore
Hydro	No	Yes	Ignore
Geothermal	No	Yes	Ignore

Table 1: Showing resources accepted and rejected.

4.3 Analysis and Simulation

The team consulted the client, the faculty advisor and several other professors of NAU with experience in the renewable resources sector on various ways to go about this project. One of the advisors wanted the team to focus the project on the effects of global warming, but the team decided not to, based on other consultations. The team would just stick to the analysis of the implementation of such a plant and the good side effects it has on global warming would just be a plus.

The clients said they would provide quantified data on all the tangible factors involved in the project based on past research. Most of this data is based on research that was done on Arizona as a whole, but we will have to customize the data to fit Coconino County. The client has provided some software models which take into consideration all the building and maintenance costs, estimates for the intangible factors, profits margins, and even cents per kilowatt hour premiums.

Aside from the simulation software, the team would also use case studies to assist in choosing the right estimates for the software. The team would be considering a solar plant and a wind farm compared to a clean coal plant. The client will provide the team all the data they need for the project.

The team would exhaustively test all their simulations to make sure we come up with reasonable results. Software models would be provided for each of the two renewable resources. Since the team would be doing a cost benefit analysis, the team would have to quantify all the factors involved in the research. Since we have to quantify the non-tangibles, the team would start with estimates and then do a lot of testing to make sure we come up with reasonable results using all the data provided by the client.

Even though we are assuming that the tangible costs of the renewable resources would come up a little higher than clean coal, introducing the cost of the intangible factors would make them more competitive with the fossil fuels. The fossil fuels have a higher cost when it comes to the intangible factors like effects of CO_2 emissions as well as the health effects of air, land and water pollution. Also, with the sky rocketing prices of the fossil fuels, it is seen that the tangible costs would keep going higher and higher in the near future, while, that of the renewable resources would minimally change if it changes at all.

4.4 Project Materials

Table 2 below contains a list of the materials that have been provided for our project. Most of the project materials have been provided by either NAU or our sponsor.

Project Material	Provided By
Wind Data	APS/SEDI
Solar Data	APS/SEDI
Computers for Project	NAU

Table 2: Project Material List

4.5 Constraints

Our main constraints are environmental constraints, cost constraints, sustainability constraints and social/ political constraints.

Our end goal is to offset current costs of building a renewable energy power plant in Coconino County by analyzing the benefits. We hope to get a cost that is reasonable when compared to fossil fuel energy. We primarily intend to show that the initially higher cost of renewable energy will be offset by the savings from the intangible benefits. So our recommendation must gravitate toward an energy source that does not cost more than the market will bear.

Part of our end goal is that our recommended power source will help make Coconino County sustain itself with resources produced in the county as opposed to importing them. An example of a resource we would not want to import is construction equipment. The construction of the plant should be done by a local company to keep profits within the county. To that end, our power source needs to use as many resources as possible from within the county so that it provides new jobs and new contracts for local businesses. We cannot reasonably recommend a renewable energy strategy that would mostly benefit Phoenix, for example.

Our recommended source must be as environmentally friendly as possible. That means we should look towards preserving air, land, and water quality with our recommended renewable source over fossil sources. We need to also take into account any side effects of our chosen location so that we don't significantly affect any habitats or ecosystems.

The political constraints of this study are that it must benefit Coconino County and be agreeable to APS and SEDI. It would do no good to recommend a renewable energy strategy that is not in line with the visions of SEDI and the engineering constraints of APS. We also have to consider public perception of any renewable source we might choose. We cannot recommend a source that would ruin the beauty of the community or destroy any well-loved wilderness/camping areas. We also need to consider the impact our source will have on water usage in the county as well as land area usage and its impacts on ranchers.

5.0 Budget

This section contains the estimated cost of materials needed for the project. Also contained are the payment and reimbursement plans for monies spent on the project.

5.1 Bill of Materials

Table 3, shown below, gives the costs for the materials we will need for our project. Costs are estimated, when given. Estimated costs are based upon an average of costs of the needed items that were found at various stores on the web.

Project Material	Estimated Cost
Clean Coal Data	Free
Wind Data	Free
Solar Data	Free
Dreamweaver Web-design Software	$200
Computers for Project	Free

Table 3: Estimated Costs of Project Materials

5.2 Payment and Reimbursement

Due to the fact that our project is extremely low cost to us and our sponsors, we have decided as a team, along with our sponsors the following payment plan: When the team needs to purchase something for the project, we will send a written request to Steve Catanach, our APS sponsor. Steve will then purchase what we need and get it to us in a timely manner. At this time we have not asked for the purchase of the Dreamweaver software.

6.0 Proposed Project Schedule

This section includes the project deliverables, a work break-down structure (WBS), and a copy of the Power Point® presentation that we gave to our class. The project deliverables are a list of what is to be turned in for the remainder of the project. The WBS contains a specific timeline of events regarding our analysis. If the WBS is followed, our analysis will be done efficiently and on time.

6.1 Deliverables

Table 4 below shows a list of project deliverables that are known thus far. Throughout next semester, there will inevitably be more tasks added to our project, but the major deliverables are given here. Some of the deliverables have already been completed, as indicated by the due date.

Deliverable	Due Date
Project Activity Report 1	10/23/07
Client Status Report Draft	10/26/07
Client Status Report	11/02/07
Project Activity Report 2	11/06/07
Project Activity Report 3	11/20/07
Client Proposal Draft	11/30/07
Proposal Presentation	12/04/07
Client Proposal	12/07/07
Website	02/18/08
Presentation 2	02/25/08
Client Status Report	03/03/07
Celebration of Undergraduate Research and Design	04/18/07
Final Project Report	05/02/07

Table 4: Project Deliverables

6.2 Work Break-down Structure

Table 6 below shows our proposed schedule for working on the project. In the past months, much research has been done. The remaining work is to tie a base cost to each benefit. This cost should be in

dollars per Kilowatt-Hour. We will get the costs associated with a clean coal plant first. We will then get the costs associated with wind and solar plants. We will compare the renewables to clean coal and use our findings to assess the benefits.

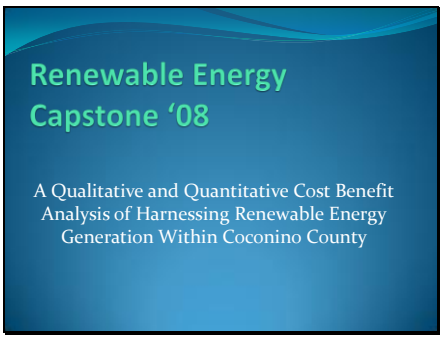
Task	Target Completion Dates
Base Case – Clean Coal: 1. Research the technology 2. Quantify environmental, social, and economic factors associates with clean coal.	February 10 – February 20 Completed
Alternative 1 – Wind Energy 1. Research different technologies 2. Quantify environmental, social, and economic factors associated with wind energy.	February 20 – March 15
Alternative 2 – Solar Energy 1. Research different technologies 2. Quantify environmental, social, and economic factors associated with solar energy.	March 15 – April 1
Compare and Conclude	April 1 – April 10
Write Final Report	April 10 to May 2nd

Table 6: Work Breakdown Structure

6.3 Power Point® Presentation

The Power Point® presentation in this section was given to the class.

Slide 1



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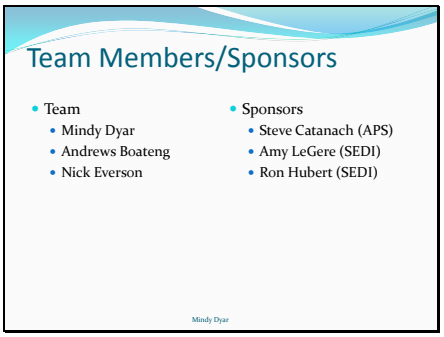

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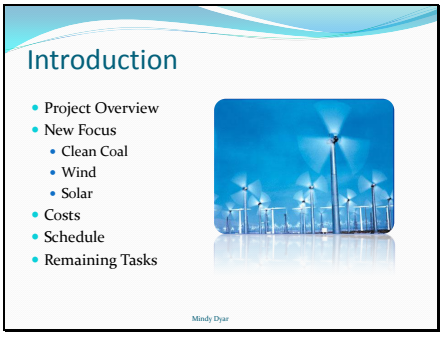

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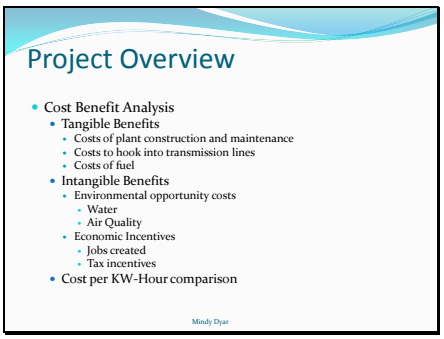

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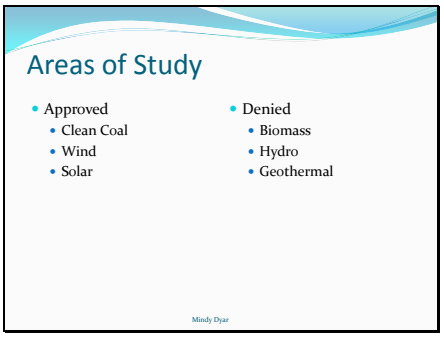

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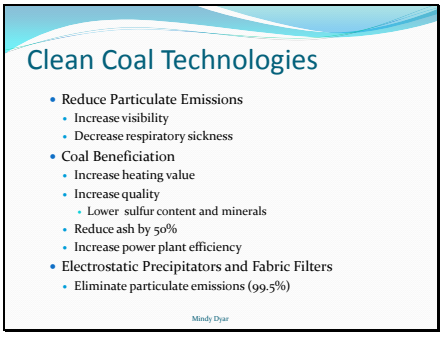


Slide 7

Clean Coal Incentives

- Prevent Acid Rain
  - Sulfer (SOx)
  - Nitrates(NOx)
  - Mercury
  - PFBC
- Reduce CO_2 Emissions
  - Increase combustion efficiency
  - IGCC
  - CCS

Mindy Dyar

Slide 8

Clean Coal Incentives

- 5% CO_2 Reductions
  - Coal Cleaning
- 22% CO_2 Reductions
  - Improved Efficiency
- 25% CO_2 Reductions
  - Integrated Gasification Combined Cycle
  - Pressurized Fluidized Bed Combustion
  - Integrated Gasification Fuel Cells
- 99% CO_2 Reductions
  - Carbon Capture and Storage

Mindy Dyar

Slide 9

Economic Incentives

•Types of jobs created:

- •Direct jobs: the jobs that are created as a result of the immediate effect of project expenditures. Jobs like contractors and local manufacturing.
- •Indirect Jobs: the ones that are created due to an increase in local economic activity like bankers.
- •Induced jobs: are the type of jobs that are created as a result of the change in wealth that occurs from the spending habits of the people with the Direct and Indirect Impact jobs.

GE 1.5MW turbine being installed by workers

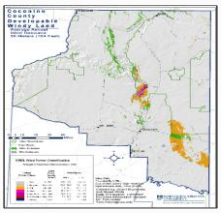
Andrews Boateng

Slide 10

Windy Land

•Wind is classified in into 7 different classes due to their speeds:

- •Class 7: > 8.8 m/s
- •Class 6: 8.0 – 8.8 m/s
- •Class 5: 7.5 – 8.0 m/s
- •Class 4: 7.0 – 7.5 m/s
- •Class 3: 6.4 - 7.0 m/s
- •Class 2: 5.6 – 6.4 m/s
- •Class 1:< 5.6 m/s



Windy land in Coc. County

Andrews Boateng

Slide 11

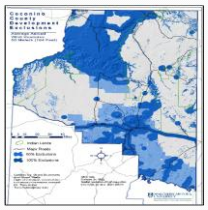
Developable Land

•Developable land is land that does not fall within any of the development exclusions

•Exclusions include:

- • environment (organizational), land use (airports, urban use), land characteristics (slope)

Land ownership in Coc.Co.



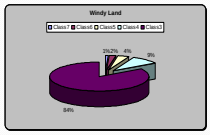
Developable land in Coc. County

Andrews Boateng

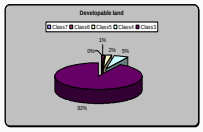
Slide 12

Development

- 3% of the land (559 miles^2) is considered to be both windy and developable
  - 92% (514 miles^2) experiences Class 3 type wind.
  - 60MW wind farm needs about 0.4 miles^2 to operate with class 3 type winds using a 40% efficient 1.5MW wind turbine



Wind experienced in the Coconino County



% of wind experienced after all exclusions are removed

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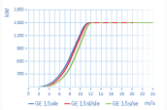
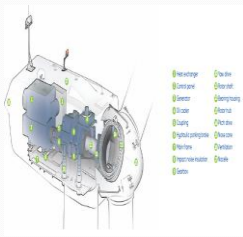
Wind Technology

•GE 1.5 MW wind turbine

- Cut in wind speed of 3.5 m/s, cut out wind speed of 25 m/s
- •Diameter of rotor is about 75m with swept area of about 4420 m². It's light and has little noise and can be erected between 61.4-100 m
- •It also has an efficiency of 40% at class 3 winds ($P = 0.5*\pi*\rho*r^2*v^3$)

Power Curve





Parts of the 1.5MW turbine

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Wind

•Wind analysis is done with both the JEDI Model and Monte Carlo Simulation

•JEDI model: is the Job and Economic Development Impact is an MS Excel based software developed by National Renewable Energy Lab (NREL) for the purpose of doing a cost benefit analysis for wind farm projects

•Monte Carlo simulation is a method of statistical analysis where input parameters that are uncertain are entered as a range of values. The average is then used.

GE's 1.5 MW wind turbine

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Analysis

JEDI model and Monte Carlo Simulation for 60MW wind farm

Year of Construction	2008	Local Spending	$11,224,951
Project Location	ARIZONA	Total Annual Operational Expenses	$15,800,400
Project Size - Nameplate Capacity (MW)	60	Direct Operating and Maintenance Costs	$930,000
Turbine Size (KW)	600	Local Spending	$707,492
Number of Turbines	100	Other Annual Costs	$14,870,400
Construction Cost ($/KW)	$1,600	Local Spending	$432,000
Annual Direct O&M Cost ($/KW)	$15.50	Debt and Equity Payments	$0
Money Value (Dollar Year)	2007	Property Taxes	$272,000
Project Construction Cost	$96,000,000	Land Lease	$160,000

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Summary of Analysis

	Jobs	Earnings	Output
During construction period			
Direct Impacts	82	$4.1	$11.0
Construction Sector Only	79	$3.9	
Indirect Impacts	36	$1.3	$3.5
Induced Impacts	51	$1.6	$5.0
Total Impacts (Direct, Indirect, Induced)	**169**	**$7.1**	**$19.5**
During operating years (annual)			
Direct Impacts	11	$0.5	$0.9
Plant Workers Only	5	$0.3	
Indirect Impacts	3	$0.1	$0.3
Induced Impacts	6	$0.2	$0.6
Total Impacts (Direct, Indirect, Induced)	**19**	**$0.8**	**$1.8**

Notes: Earnings and Output values are millions of dollars in year 2007 dollars. Construction related jobs are full time equivalent for the construction period

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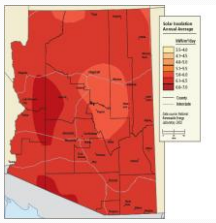
Solar Power

- Solar
  - Arizona has the largest solar resource of any place in the world.
    - According to NREL's renewable energy resource atlas of Arizona, most areas have high to very high concentrations.



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Solar Power Technologies

- Solar Thermal
  - Parabolic trough
  - Parabolic dish
  - Power tower
  - Compact Linear Fresnel Reflector (CLFR)
- Solar Photovoltaic
  - Most cells are about 10% efficient.
  - Advanced designs give as much as 40% efficiency.

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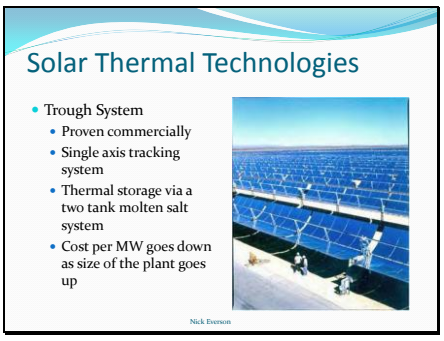

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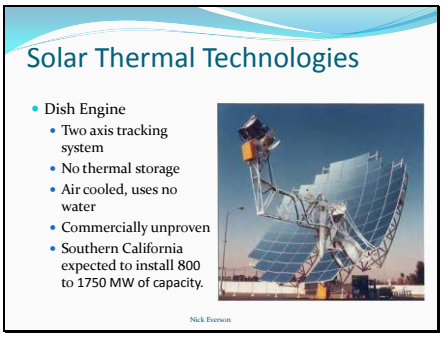

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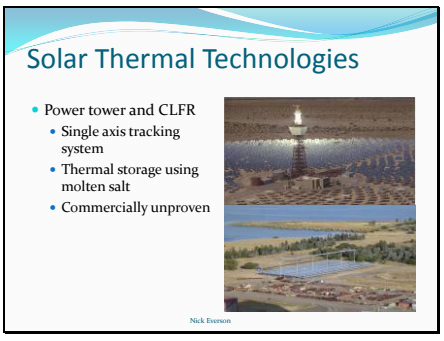

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Solar Photovoltaic

- Flat panel photovoltaic
  - Commercially available
  - Less sunlight required than thermal systems
  - Cost remains high due to expense of silica

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Slide 23

Solar Photovoltaic

- Dish and lens concentrators
  - Commercially available
  - Uses less silicon cells than flat panels
  - Their proposed cost savings have yet to be proven
  - Might be ideal for high efficiency cells

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Solar Photovoltaic

- The potential for photovoltaic solar to supply Arizona's energy needs is high.
- According to the NREL table below all of Arizona's daytime energy needs could be satisfied with PV solar alone.

Table 4-15. Theoretical Solar Power Production in Arizona.

Total Theoretical Solar Annual MWh PV Production in Arizona	123,500,000
Arizona Total Annual MWh Generation 2005	101,478,654

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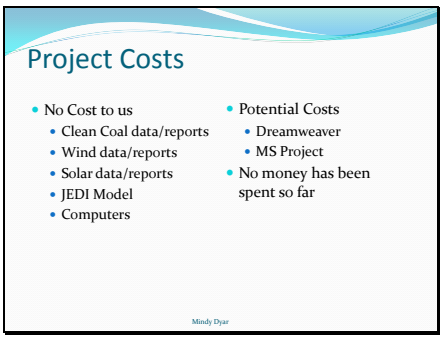

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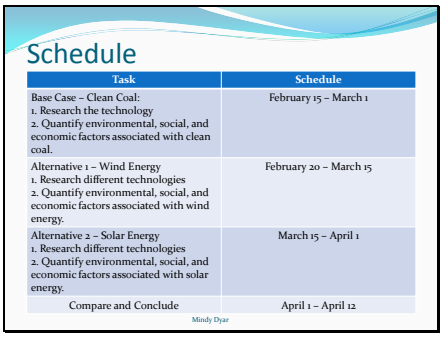

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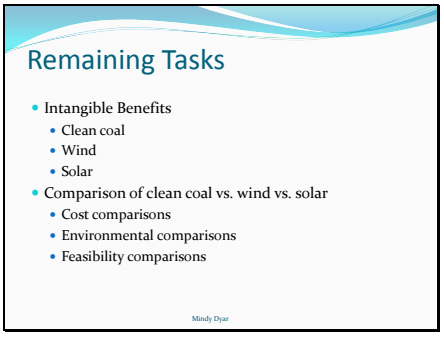

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Conclusion

- Project Overview
- New Focus
  - Clean Coal
  - Wind
  - Solar
- Costs
- Schedule
- Remaining Tasks

Mindy Dyar

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References

- Black and Veatch Corporation. (2007). *Arizona Renewable Energy Assessment.* Overland Park: Black and Veatch.
- Madsen, T., & Brown, D. E. (2005). *Renewing Arizona's Economy.* Phoenix: AZ PIRG Education Fund.
- Williams, S., Acker, T., Brummels, G., & Wells, S. (2007). *Arizona Wind Energy Assessment.* Flagstaff: Sustainable Energy Solutions.
- World Coal Institute. (2005). *The Coal Resource.* Putney: World Coal Institute.
- www.nrel.org

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Questions?

7.0 Client Acceptance Document

You will find the Client Acceptance Document on the next page, which should also be the last page of this packet. The document contains a disclaimer for liability and an ownership statement. If you do not accept our proposal, please get in touch with us so that we may revise it in a timely fashion.

Acceptance Document

This letter is intended to serve as an acceptance document for the client and/or for further negotiation of the terms of the proposal. Please sign and return this letter no later than April 10th. If further negotiation of terms is needed, please let us know by April 15th, at which time a meeting will be arranged to discuss the terms.

By signing this document the client agrees to all terms listed in the cover letter and proposal document. Furthermore, the client recognizes that the students of EE486 are not responsible for issues of liability arising from this project. The client must recognize that if our study is used further, the names of Mindy Dyar, Andrews Boateng, and Nick Everson will be cited as the authors of the research, however, the concluded project research will be owned by APS and SEDI. By signing this document, the students of EE 486 pledge to approach our project as outlined in the proposal and deliver the cost benefit analysis as scheduled.

Signed (Client, Steve Catanach)	**Date:**
Signed (Client, Amy LeGere)	**Date:**
Signed (Client, Ron Hubert)	**Date:**
Signed (Student, Mindy Dyar)	**Date:**
Signed (Student, Andrews Boateng)	**Date:**
Signed(Student, Nick Everson)	**Date:**