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APS and SEDI Sponsors
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Dear APS and SEDI Sponsors:

First, the Renewable Energy Capstone Team would like to thank you for giving us the opportunity to do such an academically diverse project. We are lucky that we were able to learn about renewable energy on the generation level and the many benefits that it could bring our county.

We would also like to thank you for attending our capstone presentation. Overall, we think it went very well. We had some good questions, but we did our research so we were able to answer them all. Our poster session in the morning also went well. We had many questions and it seemed that many people were interested in our project.

Since the last letter, we have completed the analysis. Wind and solar benefits were compared to clean coal on the power generation level. The summary is in the form of a table where we show our predicted end-cost of generation in cents/kWh. We decided on a table because it is easier and more interesting to read than if it were report-style.

We learned so much about renewable energy in this project. We also learned that Arizona has great potential to harness it. We are happy that we were able to do this project because we know that maybe our study will be used again. Thanks again for the great project.

Sincerely,

Renewable Energies Capstone Team

Harnessing Renewable Power Generation within Coconino County

A Qualitative and Quantitative Cost Benefit Analysis

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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.

Website:

http://www.cens.nau.edu/Academic/Design/D4P/EGR486/EE/08-Projects/APSRenewable/

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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 section is the problem overview section. 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 the problem's background, benefits to the client, and a system diagram.

The next section in the report is the design section. The first item in this section is the requirements and a narrative of how the team met them. The next item in the section describes the research phase of our project. Following is the approach. This is where we describe how we did our analysis. Following is the analysis where we compare the generation technologies. Last is the summarization. We give the results to our analysis here. We discuss the process the team went through as well as decisions and difficulties we had in each section.

Next, the budget section follows the design section. The budget section contains a list of materials we used for the project. Also, time spent was broken down in this section in man-weeks or 40 hour blocks. Also included is the final schedule. This is a list of the deliverables we had through the project and when they were completed.

The last section contained in this report has the project deliverables. First the wind analysis is given then the solar analysis. After that is the comparison table with summary. The last item is our final PowerPoint presentation.

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.

2.2 Background

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.

2.3 Benefits

Our project was a cost benefit analysis of a renewable resource in the county. After initial research, we only had to analyze solar and wind against clean coal respectively in three different size plants: 60MW, 120MW and 500MW.

Even though we know that renewable resource type of plant is more beneficial both for the people (including the client) and the environment, we still had to quantify all the tangible and intangible benefits. So, one of the benefits our client would get is quantified data in terms of water usage. They would also get numbers on the amount of jobs created during the construction and O&M period, how much revenue would be generated if power is exported to other counties and states.

Secondly, the client would also get quantified data in terms of emissions produced by each of the resources for the three different plants. This would also reflect on how much people are saving in terms of healthcare costs. Finally, the client would also get data on how much his customers would be really paying if any of the resources is implemented in the Coconino County based on all the quantified data from the research for the three different sizes.

2.4 System Diagram

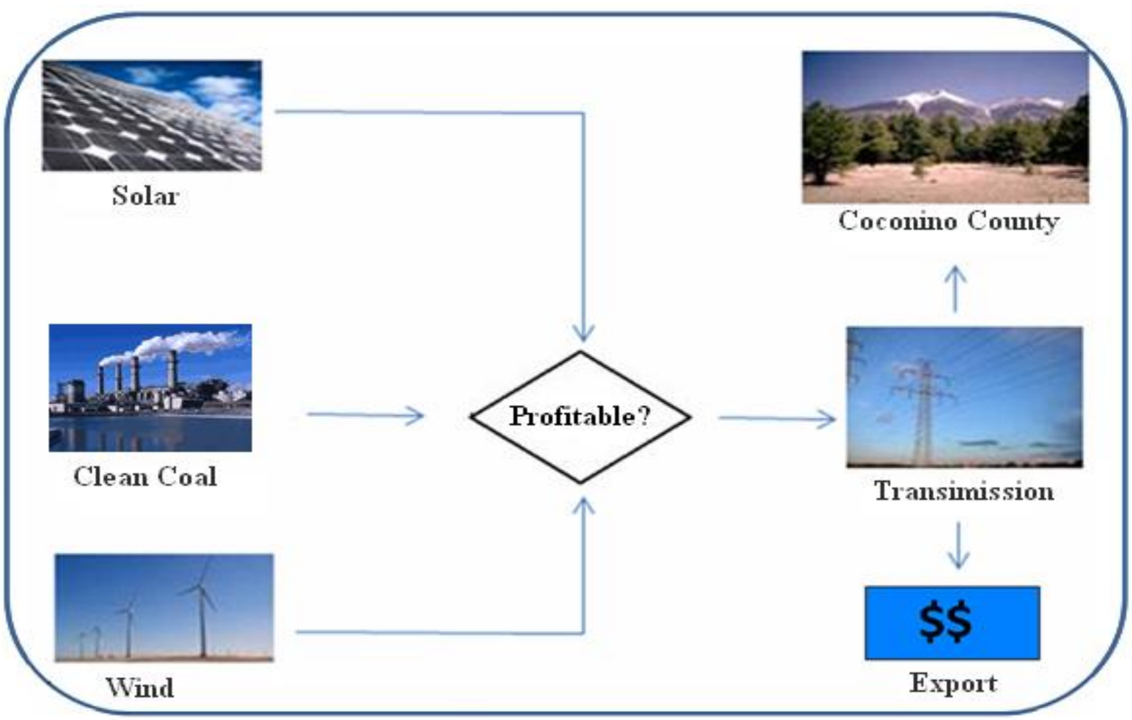


Figure 1 – Diagrammatic Representation of Project

3.0 Design Section

This section contains the bulk of the report. Included first is a list of the requirements and how our team met them. After that, the four phases of the project are covered in detail. The four phases were research, approach, analysis, and summarization. Each section provides details on how we completed our analysis.

3.1 Requirements

Our project had to meet requirements which included: Mechanical, Economical Impacts, Environmental and Social. Mechanically, the team researched and chose the technology that had the most benefit in terms of its size and efficiency of the units. For wind we went with the GE 1.5MW wind turbine which has the best efficiency (40%) at class 3 level winds (84% of wind is class 3).

For solar we went with the Parabolic Trough, which also has an efficiency of about 40%. The team did not go with either the photovoltaic cell or the sterling engine due to the fact that the PV cell has 12% - 14% efficiency and the sterling engine is unproven so it attracts high interest loans with the banks. In terms of Economic Impacts, the resources we analyzed would provide jobs both in the construction and the O&M periods. The jobs created would also increase tax revenues generated in the county. There is an increase of 1.4% -1.8% of the property value of the land due to the installed equipment on the land. This would generate revenue for the county due to the property tax generated. The implementation of such a plant would also attract other investors which would in turn also generate more revenue for the county.

Environmentally, the renewable resources provide a cleaner one due to the little (solar) to no (wind) emissions produced in running the plant in the county, also, both resources would be able to operate under temperate conditions. Consequently, this would also decrease the healthcare cost of the people which is a social requirement. Due to the fact that the renewable resource plants do take up a lot of land farmers and ranchers could lease out part of their land to our client instead of being totally displaced. So socially, farmland and ranchland would be preserved. There is also less to no dependent on foreign resources so prices would be stable so that would benefit the county both socially and economically. Finally, we also provided how much the client’s customers would be paying in each of the three size plants for all the resources we analyzed.

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

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. 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

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.

b. 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.

3.2 Research Phase

In our research phase we had to start by getting a clear definition of what our problem was and finding out what our client wanted from the project. To this end we first scheduled several meetings. We found out that what our client was looking for was some insight into the side benefits of renewable energy. We were also able to narrow down the scope of our research phase by eliminating power generation methods that were definitely not going to be built in the county. We ended up eliminating geothermal power and hydroelectric power.

With three sources of renewable energy left to study, we began to look more in depth at the various technologies. We looked at several technologies of solar power, biomass and wind power. We found specific benefits and draw backs for each technology. The challenge of this phase of our project was that there was so much information and to sort through it was cumbersome. Also, it was hard to tell if resources were legit or if they were just advertising or trying to voice their opinion. We learned that only a handful of the resources we had access to were unbiased.

3.3 Approach Phase

In this phase we conferred with our client so we could show him our findings on solar, biomass and wind power. With our client, we decided that our approach to the project would be a comparison of renewable energy to "clean coal" technologies. This approach was chosen because renewable energy is initially more expensive than coal power. By comparing renewables with "clean coal" we would be able to level the playing field cost wise.

The remainder of our approach involved studying the "intangible" benefits of renewable energy. Our overall goal was to put dollar values to things like cleaner air and water, along with preservation of ranch and farmland. The challenge we had in this phase of our project was that the scope of the project was still too large. We were able to narrow the scope even more to ensure that we had a good analysis. We learned that even though a project like this doesn't require any building, it still requires a significant amount of time to find the information you want.

3.4 Analysis Phase

For analysis we ended up narrowing our sources down to solar and wind because long term forest access permits for harvesting biomass would be too difficult to get. This led us to eliminate biomass.

Further analysis showed that only specific solar and wind technologies would be competitive with clean coal in terms of price and maturity of technology. We ended up choosing the GE 1.5MW wind turbine as it works very well in the low wind levels present in Coconino County. For solar we chose a parabolic trough CSP plant with 6 hours of storage. These technologies proved to be the best to compete with clean coal.

A challenge we had in this phase of our project was that there weren't similar models for both wind and solar. We were able to find one for wind and one for solar, but it wasn't the same one. Another challenge we ran into was finding information on smaller production coal plants, like under 500MW.

They seem non-existent, probably because they are. Overall we learned the impact and the true cost of coal to the environment and how the offset costs of renewable energy could help Northern Arizona by reducing emissions and preserving water.

3.5 Summarization Phase

We summed up our project by giving a presentation to our client and several of the engineering faculty at the capstone design conference. Our sponsor also attended this presentation. After that we organized our raw and calculated data into a succinct report that we gave to our client.

The challenge of this phase was collecting all the individual analyses together to include then all in one spot in the final report. This was a good lesson on file-naming. We learned that with good organization, things go quick and smooth. Without it, every project will take longer.

4.0 Budget

This section contains the cost of materials used in the project. Also contained are the payment and reimbursement plans for monies spent on the project. The last item in this section is a breakdown of the time spent on the project.

4.1 Bill of Materials

Table 3, shown below, gives the costs for the materials we used 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. 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. Through the entire project, we did not spend any money.

Project Material	**Estimated Cost**
Clean Coal Data	Free
Wind Data	Free
Solar Data	Free
Computers for Project	Free

Table 1: Estimated Costs of Project Materials

4.2 Time Spent

Table 2 summarized how long the team spent on the project in time and money. The table is broken up to show how much work was completed in each phase of the project.

Phases	Time/ Man-Week	Budget/ $
Research	3.75	0
Approach	5.00	0
Analysis	5.00	0
Summarization	7.00	0

Table 2: Table of the amount of time and money we spent on the project

4.3 Final Schedule

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 3: Final Schedule

5.0 Project Deliverables

This section includes the project deliverables. This includes the wind report, the solar report, the cost analysis and our final PowerPoint presentation. The project deliverables are what will be delivered to our client as the final product.

5.1 Wind Analysis

Background:

Harnessing electrical power from wind is based on the fact that energy is conserved when the kinetic energy from the wind is converted into electrical energy and a percentage lost to heat. The momentum of the wind is transferred onto the blades of the turbines which either move a magnetic field around a coil or move a coil in a permanent magnetic field to create electricity.

Technologies:

Even though there are emerging new technologies when it comes to wind technology, the main approach for plant-wise basis is the wind turbines seen across the world.

One of the emerging wind technologies is the micro wind turbine which are turbines shaped like gears that are connected together for a bigger power production. They are mainly researched for residential use (www.inhabitat.com) Another is the small blade turbines which are less noisier and it is also researched for residential use due to its size, noise level and the fact that it could be easily attached to a building (www.windenergy.com) For the purpose of building a power plant, the longer-blade wind turbines will be deployed to do the work.

Efficiency is the main factor used in selecting the right kind of turbine. Based on the equation for the amount of power generated:

$$P = \frac{1}{2}\alpha\rho\pi r^2 v^3,$$

where **α** is the efficiency factor, ρ is the mass density of air, **r** is the radius of the turbine and **v** the velocity of the air, it could be seen that a good turbine should have bigger blades and good enough efficiency. All the factors in the equation are combined in to come up with the capacity factor of a wind farm.

Methodology:

Wind is considered to be a feasible resource of electrical power if the land is considered windy. Windy land refers to land that is classified class three and up and does not fall within development exclusion. This means that the land should be have a consistent amount of wind in a land that has no restrictions (like tribal laws) on its usage.

There are several development exclusions which include:

- Environmental
    - National Park Service
        - United States National Park Service land
    - Fish and Wildlife Service
        - U.S. Fish and Wildlife Service)
    - Congressionally Specially Designated Areas
        - Wilderness or wild and scenic rivers
    - Inventoried Road-less Areas
        - Federal roads that are designated as road-less
    - State and Other Environmental Land
        - Land stewardship layer (includes Nature Conservancy Land)
    - Remaining USFS and DOD Land
        - U.S Forest Service and Department of Defense lands that remain after all exclusions are removed
- Land use
    - Urban/Developed
    - Airports

- Wetlands and Water bodies
- Non-ridge Crest Forests

- Land characteristics
  - If the slope of the land is greater than 20%

In the Coconino County, about 46% of the land is located on the Indian reservation, 32% is owned by the US Forest Service, 10% for the State of Arizona, 6% owned by private individuals and 6% is other public lands.

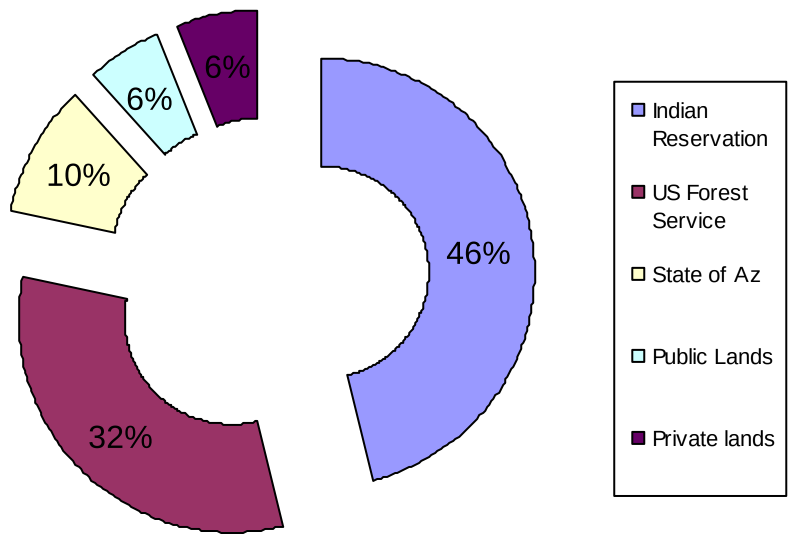


Fig1. Land Ownership in the Coconino County.

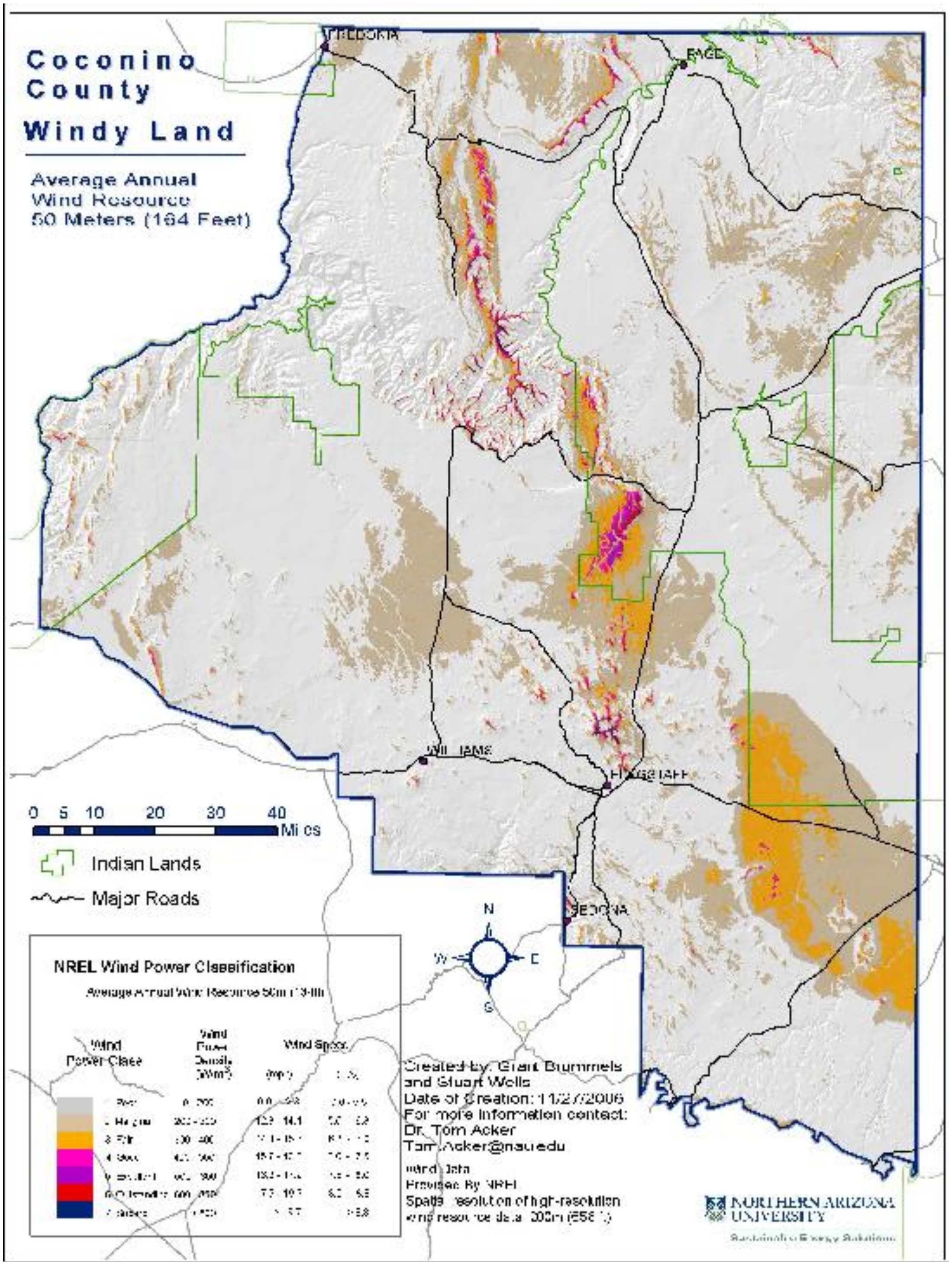


Fig1. Windy land map of Coconino County

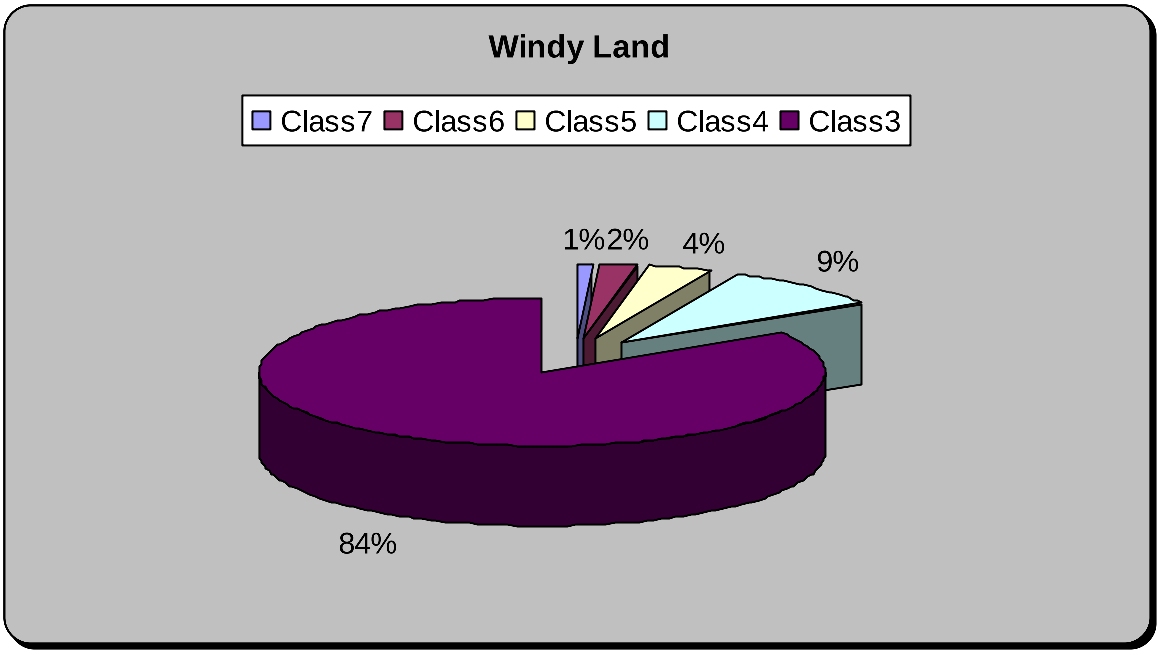


Fig2. Windy land in the Coconino County

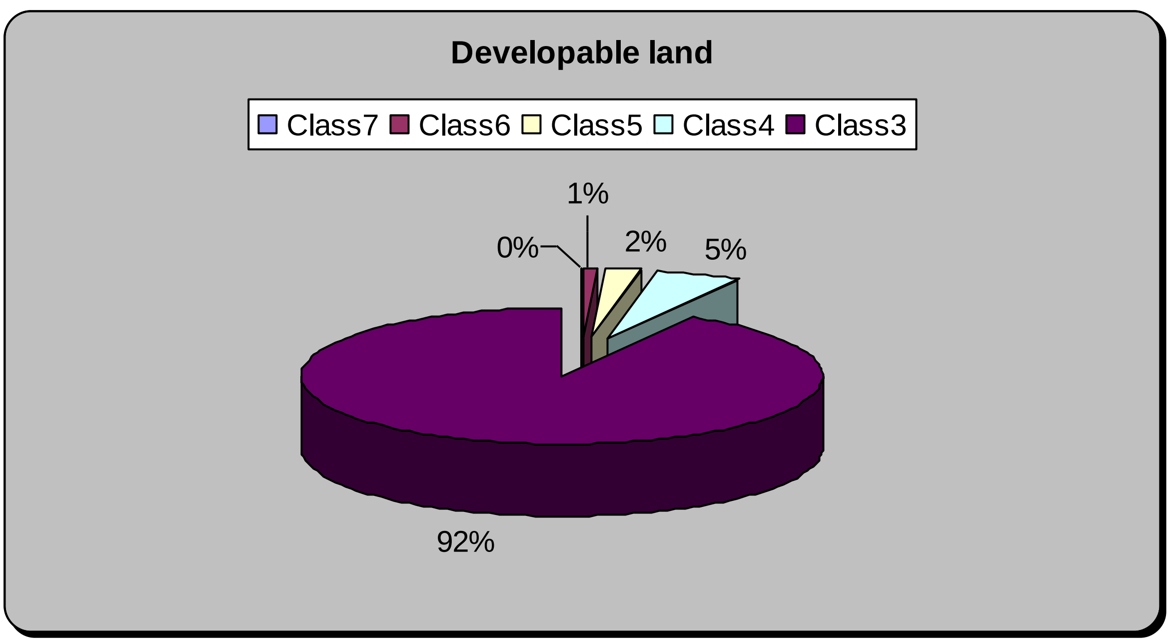


Fig3. Developable land in the Coconino County

Approximately 3% of the land is considered to be developable and windy, with winds of class 3 and higher. Based on this, it could be seen that wind is feasible in the Coconino County. About 92% of the developable land in the county, experiences class 3 type of the wind, which is 84% of the type of wind experienced on the land. The wind is not consistent but a good enough momentum could be experienced that would move the blades of the turbine until the next gust comes in. This amount of wind is capable of producing up to 7200MW of electricity.

Cost Benefit Analysis:

The cost benefit analysis for wind in the county was done with the JEDI model in conjunction with the Monte Carlo simulation. The JEDI model which stands for Job and Economic Development Impact is a Microsoft Excel based software developed by NREL (National Renewable Energy Laboratory) for the purpose of doing a cost benefit analysis for a wind plant in areas of jobs, earnings and economic output respective of the location (State). It was designed by Marshall Goldberg of MRG & Associates.

Monte Carlo simulation is a method of statistical analysis where input parameters that are uncertain are entered over a specified range of values. The JEDI model is used with the Monte Carlo simulation for certain instances where an exact value cannot be gotten in real life analysis. Since most of the wind in the county is class 3 (6.4 – 7.0 m/s) with a wind density of 300 – 400 W/m^2 at 50m, the turbine that will be considered in this analysis should be one that could function effectively at this level.

Based on this, the GE 1.5MW wind turbine was chosen since it has a cut in wind speed (low) of 3.5 m/s and a cut out wind speed (high) of 25m/s. It's light, little noise and erects vertically between 61.4 – 100m based on the customer's preference. Due to its capabilities, this 1.5MW wind turbine was able to help GE capture 47% of the market leading other suppliers like Siemens (23%) and Vestas (19%), according to the US Department of Energy's Annual Report on US Wind Power Installation, Cost and Performance Trends for 2006.

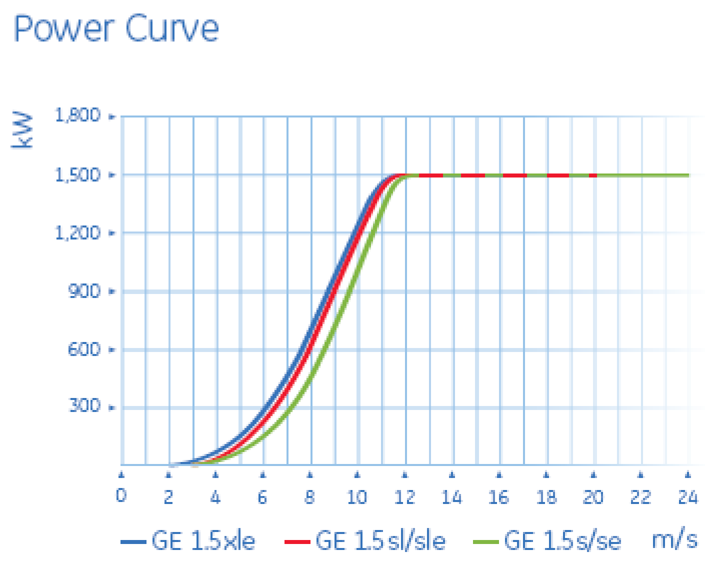


Fig 4. Power curve for the 1.5MW class Turbine.

The turbine has an efficiency of about 40% at wind speeds of the class 3 level. It mostly produces more power at higher wind classes. So, in this case the wind turbine will be mostly producing power of about 0.6 MW. Even though there is occasional higher wind speeds, for the basis of analysis, this wind turbine will be rated at 600kW. This analysis is also going to be done for three different size projects: 60MW, 120MW and 500MW.

<u>60MW analysis</u>:

Based on analysis using the JEDI model and the Monte Carlo simulation:

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

Debt and Equity Payments	$0
Property Taxes	$272,000
Land Lease	$160,000

Local Economic Impacts - Summary Results

	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 period related jobs are full-time equivalent for the construction period. Plant workers include field technicians, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures.
The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding.

Jobs

A good number of jobs are created with the implementation of wind farms. The types of jobs created can be categorized under three different groups based on how it is created. The first is called the Direct Impact jobs, and those include the jobs that are created as a result of the immediate effect of project expenditures. Jobs like contractors and local manufacturing are examples of this type. The second type in the Indirect Impact jobs and those include the ones that are created due to an increase in local economic activity like bankers. The last type is called the Induced Impact jobs and those 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.

During the construction period, there would be a total of 82 direct impact jobs, 36 indirect impact jobs and 51 induced impact jobs in the Coconino County. That means there would be a total of 169 jobs created just in the construction period. During operation, there would be 11 direct jobs, 3 indirect jobs and 6 induced jobs created annually. This means there would be a total of about 20 jobs created a year in the County as well. Since the wind plant requires less maintenance during operation, that's why there is a significant difference between the jobs created during the construction phase and the operation and maintenance phase (O & M).

Water

Minimal to no water is used in the operation of a wind turbine. In the more recent wind turbines, air is used for cooling the parts of the turbine that could overheat, so water is not used at all. Very little water is used in the manufacture of the wind turbines but the amount is negligible based on the size of the project.

CO_2

Wind technology reduces CO_2 production by a total of 2M pounds a year for 1000KW plant (according to the Honeywell renewable energy study in Coconino County). This means a 60MW wind plant would displace a total of 120M pounds of CO_2 a year, which is about 3.8 pounds a second.

Ranch Land:

Since the turbine covers an area of about 77m X 77 m and they don't stand together but are linearly arranged, farmers could lease part of their ranch land for the construction of the turbine and still undergo their ranch duties. They won't have to sell their land or move their entire ranch and would make more money leasing it to the Power Company. The value of the land would also increase generating more property tax for the county as well.

Also the property tax of the land increases by about 1.4% of the installed equipment. So, with 100 turbines, the dollar amount of the tax would be approximately $1.34M.

120MW Analysis:

Wind Plant - Project Data Summary	
Year of Construction	2008
Project Location	ARIZONA
Project Size - Nameplate Capacity (MW)	120
Turbine Size (KW)	600
Number of Turbines	200
Construction Cost ($/KW)	$1,600
Annual Direct O&M Cost ($/KW)	$15.50

Money Value (Dollar Year)	2007
Project Construction Cost	$192,000,000
Local Spending	$22,449,903
Total Annual Operational Expenses	$31,600,800
Direct Operating and Maintenance Costs	$1,860,000
Local Spending	$1,414,983
Other Annual Costs	$29,740,800
Local Spending	$864,000
Debt and Equity Payments	$0
Property Taxes	$544,000
Land Lease	$320,000

Local Economic Impacts - Summary Results

	Jobs	Earnings	Output
During construction period			
Direct Impacts	164	$8.2	$21.9
Construction Sector Only	157	$7.8	
Indirect Impacts	73	$2.6	$7.0
Induced Impacts	101	$3.3	$10.0
Total Impacts (Direct, Indirect, Induced)	**338**	**$14.1**	**$39.0**
During operating years (annual)			
Direct Impacts	22	$1.0	$1.9
Plant Workers Only	11	$0.6	
Indirect Impacts	5	$0.2	$0.6
Induced Impacts	12	$0.4	$1.2
Total Impacts (Direct, Indirect, Induced)	**39**	**$1.6**	**$3.6**

Notes: Earnings and Output values are millions of dollars in year 2007 dollars. Construction period related jobs are full-Time equivalent for the construction period. Plant workers include field technicians, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding.

<u>Jobs:</u>

During the construction period, a total of 338 jobs are created just in the construction period. Out of the 338 jobs, 164 of them are direct impact jobs, 73 are indirect impact jobs and the remaining 101 jobs are induced impact jobs.

However during the operation and maintenance phase a total of 39 jobs are created annually. Of all these, 22 are direct impact jobs, 5 are indirect impact jobs and then 12 are induced impact jobs.

<u>Water:</u>

A minimal amount of water is used in both the construction and O&M phase of the plant. The wind farm helps conserve water for human and other uses.

CO_2:

According to the Honeywell renewable energy study in Coconino County, a 120MW wind plant would displace a total of 240M pounds of CO_2 a year, which is approximately 7.6 pounds a second.

Ranch Land:

Farmers won't have to sell their land or move their entire ranch, they could just lease part of their ranch land for the construction of the turbine and still undergo their ranch duties. The farmers would make more money, and the value of the land would also increase generating more property tax for the county. Also the property tax of the land increases by about 1.4% of the installed equipment. So, with 200 turbines, the dollar amount of the tax would be approximately $2.7M.

500MW Analysis:

Wind Plant - Project Data Summary	
Year of Construction	2008
Project Location	ARIZONA
Project Size - Nameplate Capacity (MW)	500
Turbine Size (KW)	600
Number of Turbines	834
Construction Cost ($/KW)	$1,600
Annual Direct O&M Cost ($/KW)	$15.50
Money Value (Dollar Year)	2007
Project Construction Cost	$800,000,000
Local Spending	$93,541,261
Total Annual Operational Expenses	$131,671,067
Direct Operating and Maintenance Costs	$7,750,000
Local Spending	$5,895,763
Other Annual Costs	$123,921,067
Local Spending	$3,601,067
Debt and Equity Payments	$0
Property Taxes	$2,266,667
Land Lease	$1,334,400

Local Economic Impacts - Summary Results

	Jobs	**Earnings**	**Output**
During construction period			
Direct Impacts	683	$34.3	$91.4

Construction Sector Only	655	$32.6	
Indirect Impacts	302	$11.0	$29.1
Induced Impacts	423	$13.6	$41.8
Total Impacts (Direct, Indirect, Induced)	**1,407**	**$58.8**	**$162.4**
During operating years (annual)			
Direct Impacts	90	$4.3	$7.8
Plant Workers Only	45	$2.6	
Indirect Impacts	23	$0.8	$2.4
Induced Impacts	49	$1.6	$4.8
Total Impacts (Direct, Indirect, Induced)	**162**	**$6.7**	**$15.1**

Notes: Earnings and Output values are millions of dollars in year 2007 dollars. Construction period related jobs are full-time equivalent for the construction period. Plant workers include field technicians, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding.

Jobs:

Just like the other two analysis, the 500MW wind plant also creates quite a number of jobs. During the construction period, a total of 1407 jobs are created just in the construction period. 683 of these jobs are direct impact jobs of which 655 are construction sector only jobs. There are 302 indirect jobs and 423 induced jobs created during the construction phase.

At the O&M phase, 49 induced jobs and 23 indirect jobs are created. Also, there are 90 direct jobs created consequentially, which makes a total of 162 jobs just in a year.

Water:

A minimal amount of water is used in both the construction and O&M phase of the plant. The wind farm helps conserve water for human and other uses.

CO_2:

A 500MW wind plant would displace a total of 1000M pounds of CO_2 a year, which is approximately 31.7 pounds a second, according to the Honeywell renewable energy study in Coconino County.

Ranch Land:

Farmers won't have to sell their land or move their entire ranch, they could just lease part of their ranch land for the construction of the turbine and still undergo their ranch duties. This means the farmers would make more money, and the value of the land would also increase generating more property tax for the county. Also the property tax of the land increases by about 1.4% of the installed equipment. So, with 834 turbines, the dollar amount of the tax would be approximately $11.2M.

Export:

Since Coconino County uses about 120MW of electricity every hour, it means that about 380MW of electricity could be exported to other counties and states every hour. With a price of $84/MWH (according to the Honeywell study), it means that we would be selling about $31,922 every hour of energy to other counties and states.

5.2 Solar Analysis

Background

Using the sun to generate power is based on one of two methods. Thermal solar uses the sun to heat some form of heat transfer medium which is then used to turn a traditional generator. Photovoltaic solar uses semiconductor based cells to directly convert sunlight into electricity by way of the "photoelectric effect".

Technologies

Several thermal technologies and several photovoltaic technologies are currently in use or in development.

Trough systems – These systems large fields of parabolic mirrors to concentrate the sun's heat onto a heat transfer fluid. The fluid is then used in a heat exchanger to transfer the heat to water, which becomes steam used to turn a traditional turbine generator. In many installations, reservoirs of molten salt are used to store excess heat so that it can be used at night.

Dish systems – These systems use a large parabolic dish of mirrors to focus the sun's heat onto a central point where either a Stirling engine or a steam engine is located. The Stirling engine based designs require no water at all and have efficiencies of up to 40%.

Power tower systems – These systems use a field of mirrors all focused on a central tower which contains a heat transfer fluid. This heat transfer fluid is then used in a heat exchanger to turn a steam turbine generator.

Flat Panel Photovoltaic – These systems use large panels of semiconductor cells that convert sunlight directly into electricity. A DC to AC inverter then transfers the energy onto the power grid.

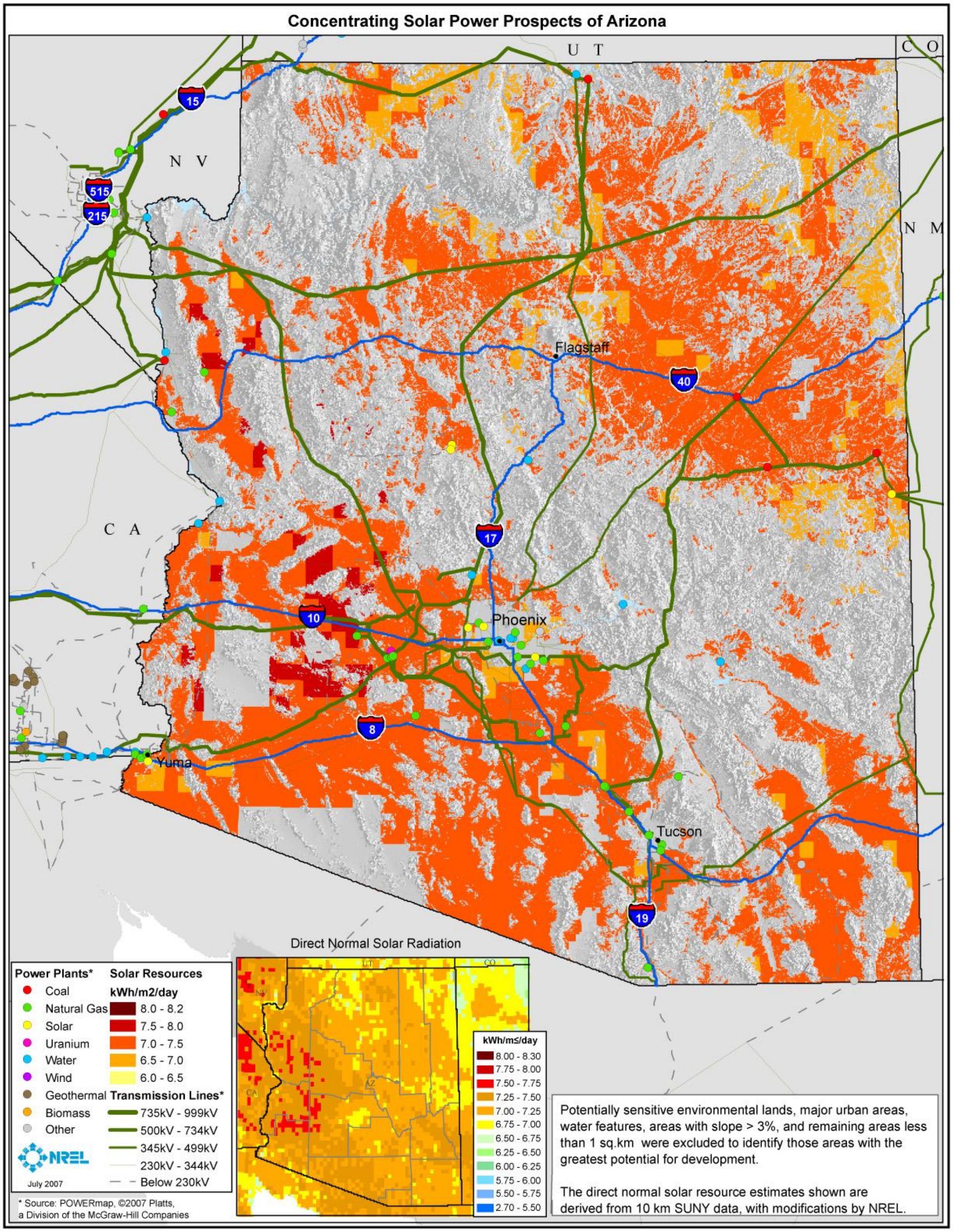
Concentrating Photovoltaic – These use lens or parabolic reflectors to concentrate more of the suns light onto a small number of high efficiency cells.

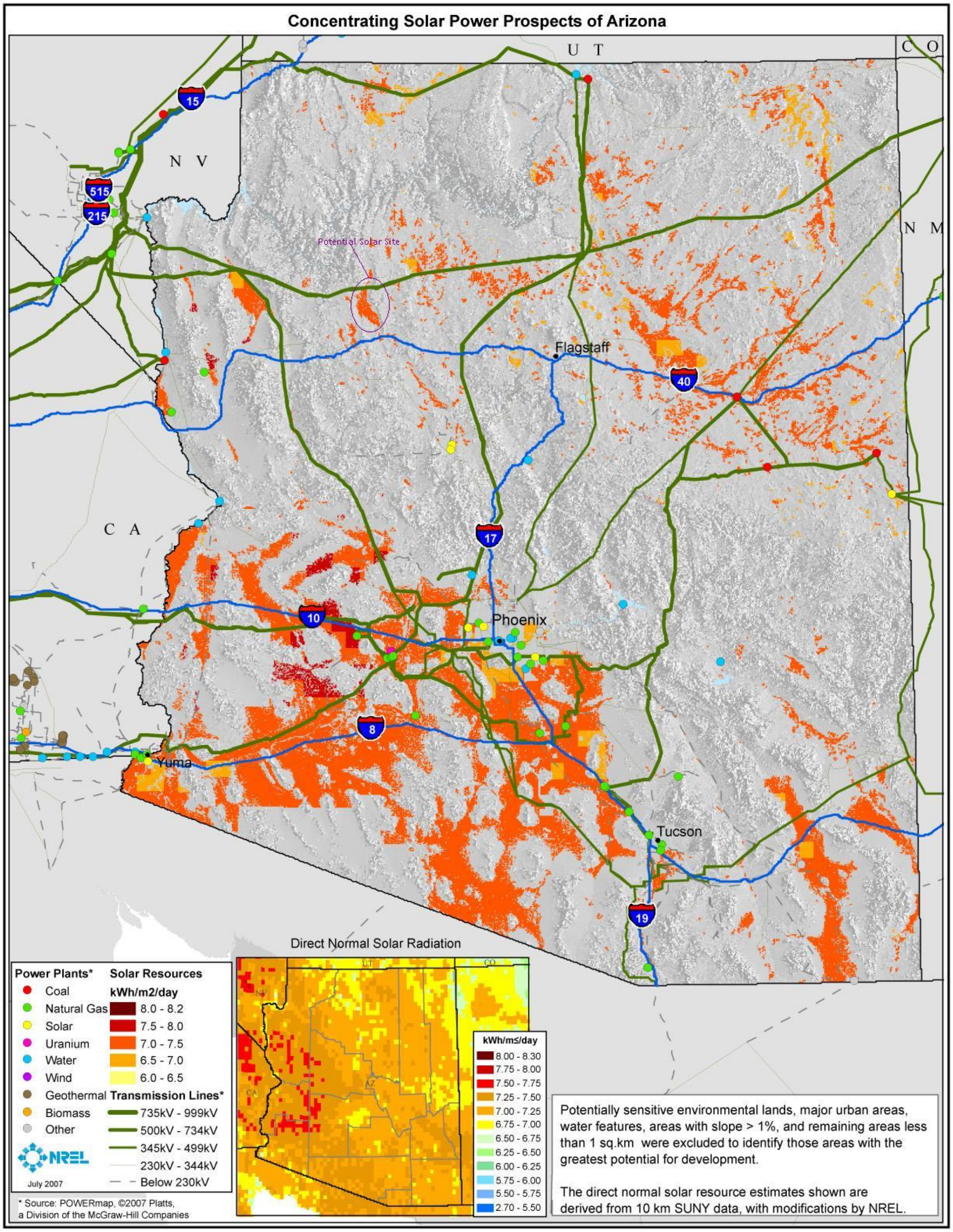
Methodology

Anywhere that the sun shines consistently is a good starting point for installing a solar plant. After that the slope of the land involved must be considered. Anywhere a slope of 3% or less exists is considered usable solar land. For a parabolic trough system, a slope of 1% of less is required. Dish systems are not covered by this analysis, but they need only 3% or less.

Shown below is a 3% solar map of Arizona, followed by a 1% map with an area circled that would be a good choice for a trough power plant. The site lies between Interstate 40 and a major transmission line and is roughly halfway between the city of Williams and the city of Kingman.

The next two maps show the same site location overlaid on a river and county map, then a tribal land map. These two maps show that the site would have access to water by way of the Big Chino Wash River, and that it would be located entirely on private land rather than tribal land.


Concentrating Solar Power Prospects of Arizona
U T
C O
N V
N M
C A
Flagstaff
Phoenix
Yuma
Tucson
15
515
215
40
17
10
8
19
Direct Normal Solar Radiation
Power Plants*
Coal
Natural Gas
Solar
Uranium
Water
Wind
Geothermal
Biomass
Other
Solar Resources
kWh/m2/day
8.0 - 8.2
7.5 - 8.0
7.0 - 7.5
6.5 - 7.0
6.0 - 6.5
Transmission Lines*
735kV - 999kV
500kV - 734kV
345kV - 499kV
230kV - 344kV
Below 230kV
NREL
July 2007
* Source: POWERmap, ©2007 Platts, a Division of the McGraw-Hill Companies
kWh/m≤/day
8.00 - 8.30
7.75 - 8.00
7.50 - 7.75
7.25 - 7.50
7.00 - 7.25
6.75 - 7.00
6.50 - 6.75
6.25 - 6.50
6.00 - 6.25
5.75 - 6.00
5.50 - 5.75
2.70 - 5.50
Potentially sensitive environmental lands, major urban areas, water features, areas with slope > 3%, and remaining areas less than 1 sq.km were excluded to identify those areas with the greatest potential for development.
The direct normal solar resource estimates shown are derived from 10 km SUNY data, with modifications by NREL.


Concentrating Solar Power Prospects of Arizona
U T
C O
N V
N M
C A
Potential Solar Site
Flagstaff
Phoenix
Yuma
Tucson
15
515
215
40
17
10
8
19
Direct Normal Solar Radiation
Power Plants*
Coal
Natural Gas
Solar
Uranium
Water
Wind
Geothermal
Biomass
Other
Solar Resources
kWh/m2/day
8.0 - 8.2
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7.0 - 7.5
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735kV - 999kV
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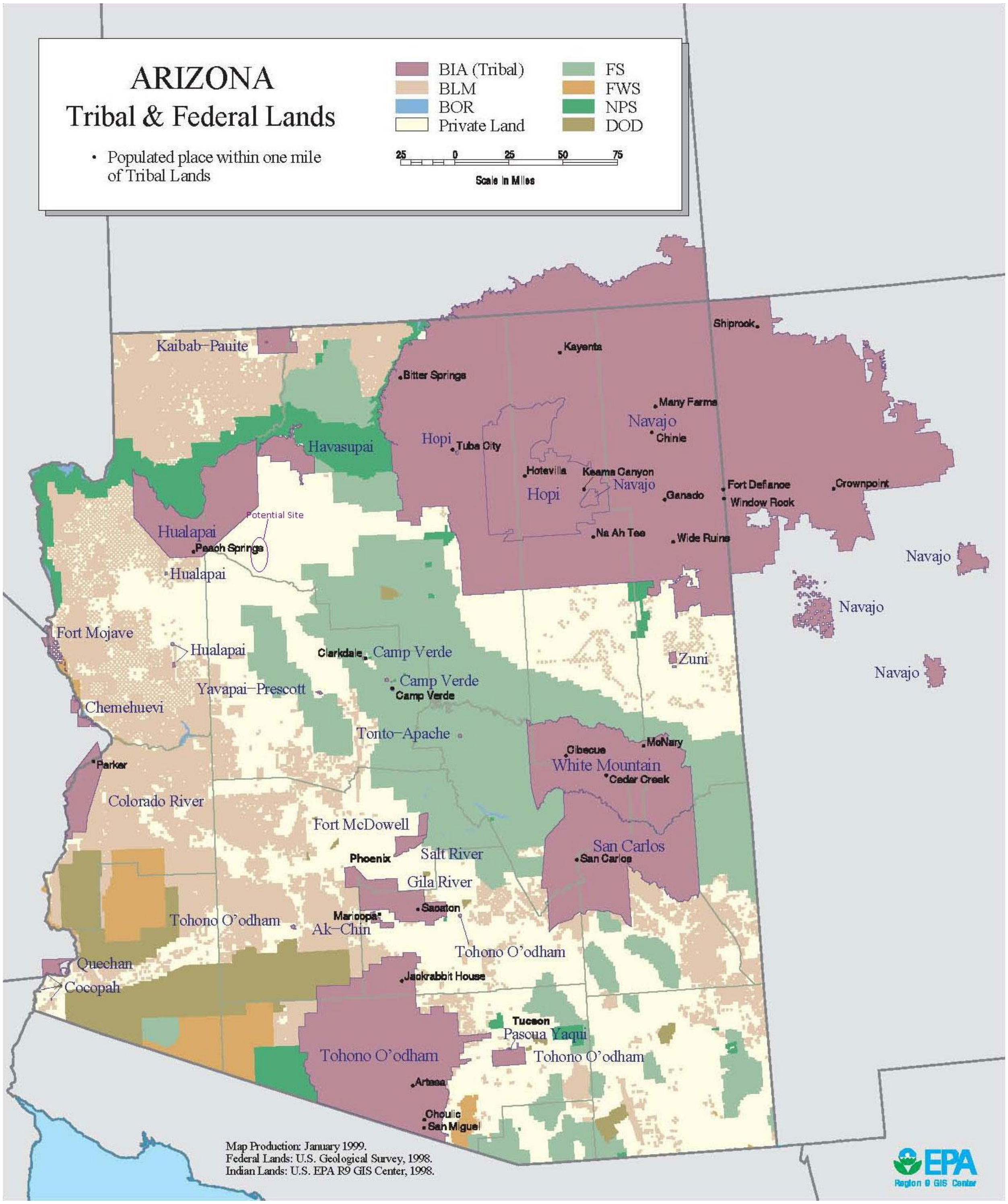
6.50 - 6.75
6.25 - 6.50
6.00 - 6.25
5.75 - 6.00
5.50 - 5.75
2.70 - 5.50
Potentially sensitive environmental lands, major urban areas, water features, areas with slope > 1%, and remaining areas less than 1 sq.km were excluded to identify those areas with the greatest potential for development.
The direct normal solar resource estimates shown are derived from 10 km SUNY data, with modifications by NREL.


Virgin R.
Kanab Cr.
Lake Powell
Navajo
Chinle Wash
Lake Mead
Colorado R.
Moenkopi Wash
Dinnebito Wash
Polacca Wash
Potential Site
Cataract Cr.
Coconino
Apache
Lake Mohave
Little Colorado R.
Pueblo Colorado Wash
Mohave
Big Chino Wash
Puerco Wash
Yavapai
Clear Cr.
Verde R.
Lake Havasu
Alamo Lake
Santa Maria R.
Bill Williams R.
Colorado R.
Hassayampa R.
Agua Fria R.
Theodore Roosevelt Lake
Salt R.
White R.
La Paz
Cintennial Wash
Black R.
Greenlee
Gila
Graham
Gila R.
San Carlos Reservoir
Gila R.
Yuma
Gila R.
Maricopa
Pinal
San Pedro R.
San Simon Cr.
San Cristobal Wash
Santa Cruz R.
Brawley Wash
Pima
Cochise
Santa Cruz
0
100 KM
100 Miles
© geology.com


ARIZONA
Tribal & Federal Lands
• Populated place within one mile of Tribal Lands
BIA (Tribal)
BLM
BOR
Private Land
FS
FWS
NPS
DOD
25 0 25 50 75
Scale in Miles
Kaibab–Pauite
Havasupai
Hualapai
Potential Site
Peach Springs
Hopi
Navajo
Tuba City
Bitter Springs
Kayenta
Shiprock
Many Farms
Chinle
Hotevilla
Keams Canyon
Ganado
Fort Defiance
Window Rock
Crownpoint
Na Ah Tee
Wide Ruins
Zuni
Fort Mojave
Chemehuevi
Yavapai–Prescott
Clarkdale
Camp Verde
Tonto–Apache
White Mountain
Cibecue
McNary
Cedar Creek
San Carlos
Parker
Colorado River
Fort McDowell
Phoenix
Salt River
Gila River
Sacaton
Maricopa
Ak–Chin
Tohono O'odham
Quechan
Cocopah
Jackrabbit House
Tucson
Pascua Yaqui
Artesa
Chuilic
San Miguel
Map Production: January 1999.
Federal Lands: U.S. Geological Survey, 1998.
Indian Lands: U.S. EPA R9 GIS Center, 1998.
EPA
Region 9 GIS Center

Cost Benefit Analysis

The cost benefit analysis of a solar plant is highly dependent on the technology chosen. Even the interest rate on the construction cost loan is dependent on the technology, with higher interest rates assessed on unproven technologies. For this reason, we chose the parabolic trough system, which has been proven as a reliable solar technology.

This study uses data from two different Black & Veatach reports along with information from the Solar Advisor model. A case study of 60 megawatt, 120 megawatt and 500 megawatt plants will be done. The solar advisor model gives land area requirements along with total project cost and cost per kilowatt hour. The Black & Veatach reports give information about the expected number of jobs created during construction and O&M.

60 MW Plant Analysis

Based on information found in the Black & Veatach Report along with information from the Solar Advisor Model.

Project Data

Year of Construction	2008
Project Location	ARIZONA
Project Size - Nameplate Capacity (MW)	60
Total Project Cost ($/KW)	$5400
Variable O&M Cost ($/MWh)	$20
Total Project Cost $	$324,000,000
Land Area Required	.9 square miles

Local Economic Impacts - Summary Results

	Jobs	Earnings	Output
During construction period			
Direct Impacts	273	$16.5	$36.6
Indirect Impacts	2100	$75.81	$204.12
Total Impacts (Direct, Indirect)	**2373**	**$92.31**	**$240.72**
During operating years (annual)			
Direct Impacts	23	$1.04	$1.89
Indirect Impacts	34	$1.12	$3.4
Total Impacts (Direct, Indirect)	**57**	**$2.16**	**$5.29**

Notes: Earnings and Output values are millions of dollars in year 2007 dollars. Construction period related jobs are full-time equivalent for the construction period. Plant workers include field technicians, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding.

120 MW Plant Analysis

Based on information found in the Black & Veatach Report along with information from the Solar Advisor Model.

Project Data

Year of Construction	2008
Project Location	ARIZONA
Project Size - Nameplate Capacity (MW)	120
Total Project Cost ($/KW)	$5400
Variable O&M Cost ($/MWh)	$20
Total Project Cost $	$648,000,000
Land Area Required	1.8 square miles

Local Economic Impacts - Summary Results

	Jobs	Earnings	Output
During construction period			
Direct Impacts	546	$27.3	$73.2
Indirect Impacts	4200	$151.6	$408.2
Total Impacts (Direct, Indirect)	**4746**	**$178.9**	**$481.44**
During operating years (annual)			
Direct Impacts	46	$2.07	$3.77
Indirect Impacts	67	$2.21	$6.7
Total Impacts (Direct, Indirect)	**113**	**$4.28**	**$10.47**

Notes: Earnings and Output values are millions of dollars in year 2007 dollars. Construction period related jobs are full-time equivalent for the construction period. Plant workers include field technicians, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding.

500 MW Plant Analysis

Based on information found in the Black & Veatach Report along with information from the Solar Advisor Model.

Project Data

Year of Construction	2008
Project Location	ARIZONA
Project Size - Nameplate Capacity (MW)	500
Total Project Cost ($/KW)	$3633
Variable O&M Cost ($/MWh)	$20
Total Project Cost $	$1,816,529,153
Land Area Required	1.5 square miles

Local Economic Impacts - Summary Results

	Jobs	Earnings	Output
During construction period			
Direct Impacts	2275	$113.8	$304.9
Indirect Impacts	17500	$631.8	$1701
Total Impacts (Direct, Indirect)	**19775**	**$745.6**	**$2005.9**
During operating years (annual)			
Direct Impacts	190	$8.55	$15.54
Indirect Impacts	280	$9.24	$28
Total Impacts (Direct, Indirect)	**470**	**$17.79**	**$43.54**

Notes: Earnings and Output values are millions of dollars in year 2007 dollars. Construction period related jobs are full-time equivalent for the construction period. Plant workers include field technicians, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding.

Job Creation

A large number of new jobs would be created during the construction phase of any size of solar plant. The first category, called direct impacts, are jobs created directly because of the plant. The second category, called indirect impacts, are jobs created because of the direct jobs. Examples of indirect jobs are auto mechanics working on the vehicles of plant workers or even grocery store employees hired to meet extra demand from plant workers. In the case of the 500 MW plant, at least one billion dollars would end up being invested in Coconino county.

Water

According to information from NREL, wet cooled parabolic trough solar systems require 920 gallons per megawatt hour for steam condensing in the generator itself and 80 gallons per megawatt hour for making up steam cycle losses and mirror washing. This results in a total water use of 1000 gallons per megawatt hour. This means that this solar technology doesn't save any water over clean coal technologies.

CO2

Carbon dioxide reduction will be considerably reduced. The 280 MW Solana plant is estimated to avoid nearly half a million tons of CO2 emissions per year over conventional fossil fuels. For the 500 MW trough installation, 900 million tons of CO2 emissions would be avoided per year.

Ranch Land

Unfortunately, the layout of a trough solar system does not lend itself well to cattle grazing. The only potential benefit for ranchers would be the money they made if their land was bought to build a solar plant.

Capacity information

Solar only works when the sun is shining. The trough systems allow for thermal storage up to 6 hours. The duty cycle of parabolic trough systems is listed as "Peaking – Intermediate", while the capacity factor is 37 to 43 percent.

Export

In the case of a 500MW solar power plant, there would be 380MW of excess electricity to export. This is based on the fact that Coconino County uses about 120MW of electricity. At a price of $84 per megawatt hour (plant ratings are in MWh) the county could export $31,920 of electricity every hour.

5.3 Comparison Table

Clean Coal

The initial cost of the coal used in the analysis is the cost to generate at Cholla power plant. This initial cost is what we assume to be the current total cost. That is, $38/MWh is the cost including water and fuel. The offset costs for coal were found by adding to existing plants the costs of newer technologies. After these three clean coal technology's costs were added to the initial cost, it is apparent that the 'true' costs of coal far outweigh its price.

The first technology is cleaning coal. By doing this, ash and particulate wastes are reduced. Another technology is called Pressurized Fluidized Bed Combustion. Using this technology results in higher efficiency for the plant as well as reduced nitrous and sulfur emissions by as much as 90% in some cases. The last technology and certainly the most expensive is Carbon Capture and Storage. This purpose of this is to protect the environment from carbon emissions. Essentially, the carbon is captured and stored underground in empty reservoirs.

After adding in the costs to clean the coal, the jobs created were looked at and deducted from the total. The end cost for coal after adding in the costs to make it clean hit $171/MWh. In the long run, coal could be the most expensive for power generation.

Wind

The wind comparison was done by taking the initial assumed cost for wind production and offsetting it with the annual fuel savings, annual water savings, and jobs created. Amounts of sulfur, ash, CO2, and nitrous emissions saved were calculated, but the costs were offset in the coal section since we could pin a price to them. Our inkling though, is that the cost to the environment outweighs the cost to implement the clean coal technologies, making wind power an even better deal.

Solar

The solar comparison was done also by taking the initial assumed cost for wind production and offsetting it with the annual fuel savings, and jobs created. Water was not an offset cost in the case of solar because solar thermal plants use as much as or more than a coal plant. Again, amounts of emissions saved were calculated, but their costs were reflected in the coal section.

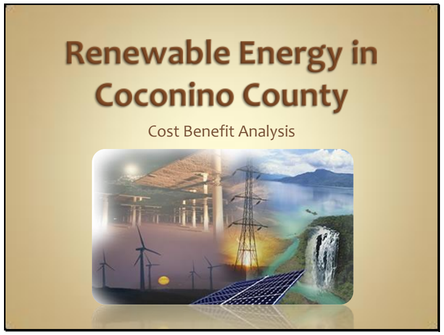
Clean Coal/Wind/Solar Cost Analysis

Clean Coal Reducing Ash and Particulates and Capturing CO_2	Generation MW	Generation Cost $/MWYr	Cost for Generation with Dirty Coal $/Yr	Fuel Usage Tons/Yr	Water Usage Gal/Yr	Coal Cleaning $/Ton	Fluidized Bed Combustion Cost $/Yr	CO2 Emissions Tons/Yr	Carbon Capture and Storage $/Yr	Jobs Created Construction and O&M	Jobs Value to County $/yr	Net Adjusted Generation Costs $/Yr	Initial Assumed Cost Cents/kWh	Adjusted Assumed Cost Cents/kWh
	500	$332,880	$166,440,000	1,051,200	6,014,178,000	$21,497,916	$300,000,000	4,432,560	$265,953,600	669	$2,792,830	$751,098,686	3.8	17.1
		Based on $38/MWh[1]		Based on 120 Tons/Hr[5]	Based on 690 Gal/MWh[6]	Based on $4.85/Ton[3]	Based On $600/kW[4]	Based on 920Kg CO2/MWh[2]	Based on $60/Ton Combusted Coal[7]					
Wind	Generation MW	Generation Cost $/MWYr	Total Production Cost $/Yr	Fuel Savings $/Yr	Water Savings $/Yr	Ash and Particulate Reduction Tons/Yr	Avoided Sox Emissions Tons/Yr	Avoided NOx Emissions Tons/Yr	Avoided CO2 Emissions Tons/Yr	Jobs Created Construction and O&M	Jobs Value to County $/yr	Net Adjusted Generation Costs $/Yr	Initial Assumed Cost Cents/kWh	Adjusted Assumed Cost Cents/kWh
	500	$946,080	$473,040,000	$36,014,112	$60,141,780	125,000	34,605	57,294	4,432,560	1,569	$6,550,000	$370,334,108	10.8	8.5
		Based on $108/MWh[8]		Based on $34.26/Ton Coal[9]	Based on $1/100Gal[10]					Based on JEDI[11]	Based on JEDI[11]			
Solar Thermal	Generation MW	Generation Cost $/MWYr	Total Production Cost $/Yr	Fuel Savings $/Yr	Water Savings $/Yr	Ash Reduction Tons/Yr	Avoided Sox Emissions Tons/Yr	Avoided NOx Emissions Tons/Yr	Avoided CO2 Emissions Tons/Yr	Jobs Created Construction and O&M	Jobs Value to County $/yr	Net Adjusted Production Costs $/Yr	Initial Assumed Cost Cents/kWh	Adjusted Assumed Cost Cents/kWh
	500	$1,471,680	$735,840,000	$36,014,112	$0	125,000	34,605	57,294	4,432,560	20,145	$84,097,992	$615,727,896	16.8	14.1
		Based on $168/MWh[8]								Based on SAM[12]	Based on SAM[12]			

1. Cholla Power Plant Average Total Cost of Generation; 2. Controlling Power Plant CO2 Emissions: netl.doe.gov; 3. Energy Citations: osti.gov; 4. PFBC: worldbank.org; 5. Responsibility Report: Pinnacle Corporation; 6. Renewing Arizona's Economy: PIRG Education Fund; 7. CCS: fossil.energy.gov; 8. AZ Renewable Energy Assessment: Black and Veatch; 9. World Price Index, 2007; 10. Residential Water Bill: April, 2008; 11. Jobs and Economic Impact Model: National Renewable Energy Laboratory; 12. Solar Aptitude Model: National Renewable Energy Laboratory

5.4 Capstone Presentation

Slide 1



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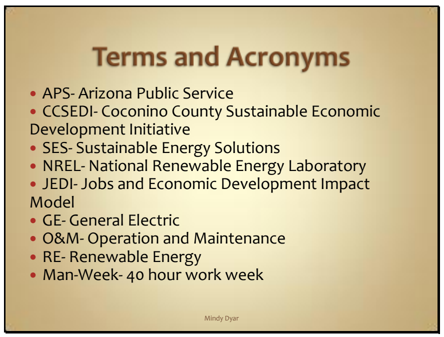
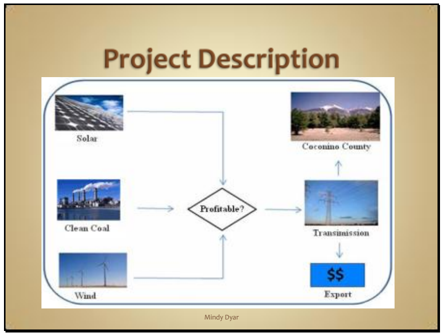


Slide 3

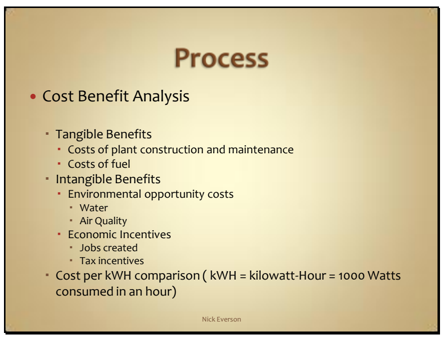
Slide 4



Explain the understandable terms, the problem being solved.

Slide 5

Slide 6



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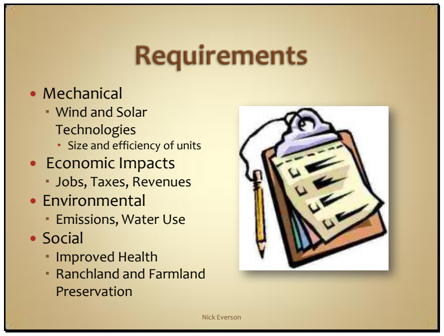

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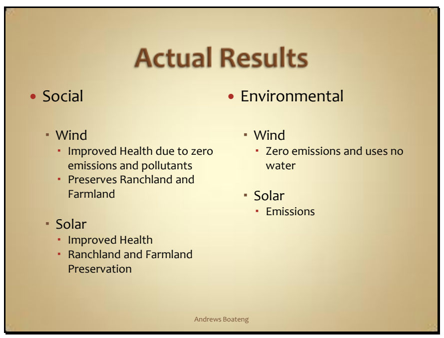
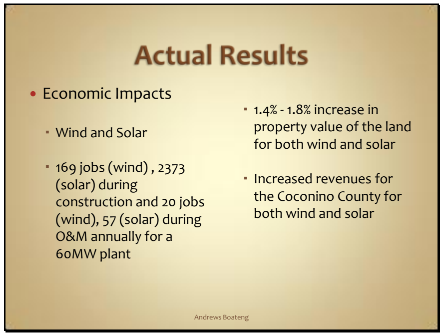
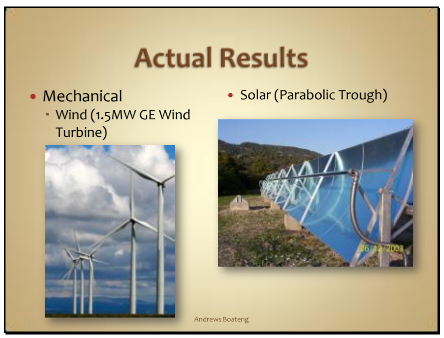


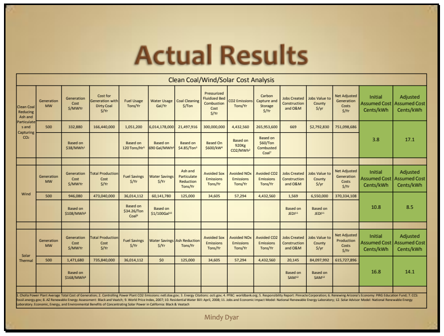
Slide 9



Slide 10



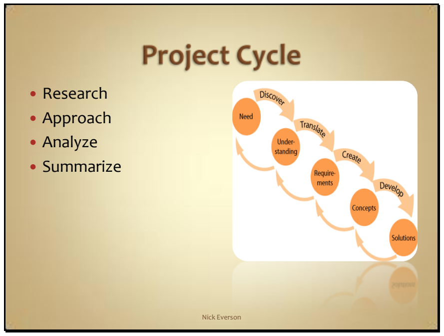
Slide 11



Clean Coal/Wind/Solar Cost Analysis															
Clean Coal Reducing Ash and Particulates and Capturing CO_2	Generation MW	Generation Cost $/MWYr	Cost for Generation with Dirty Coal $/Yr	Fuel Usage Tons/Yr	Water Usage Gal/Yr	Coal Cleaning $/Ton	Pressurized Fluidized Bed Combustion Cost $/Yr	CO2 Emissions Tons/Yr	Carbon Capture and Storage $/Yr	Jobs Created Construction and O&M	Jobs Value to County $/yr	Net Adjusted Generation Costs $/Yr	Initial Assumed Cost Cents/kWh	Adjusted Assumed Cost Cents/kWh
	500	332,880	166,440,000	1,051,200	6,014,178,000	21,497,916	300,000,000	4,432,560	265,953,600	669	$2,792,830	751,098,686	3.8	17.1
		Based on $38/MWh[1]		Based on 120 Tons/Hr[5]	Based on 690 Gal/MWh[6]	Based on $4.85/Ton[3]	Based On $600/kW[4]	Based on 920Kg CO2/MWh[2]	Based on $60/Ton Combusted Coal[7]					
Wind	Generation MW	Generation Cost $/MWYr	Total Production Cost $/Yr	Fuel Savings $/Yr	Water Savings $/Yr	Ash and Particulate Reduction Tons/Yr	Avoided Sox Emissions Tons/Yr	Avoided NOx Emissions Tons/Yr	Avoided CO2 Emissions Tons/Yr	Jobs Created Construction and O&M	Jobs Value to County $/yr	Net Adjusted Generation Costs $/Yr	Initial Assumed Cost Cents/kWh	Adjusted Assumed Cost Cents/kWh
	500	946,080	473,040,000	36,014,112	60,141,780	125,000	34,605	57,294	4,432,560	1,569	6,550,000	370,334,108	10.8	8.5
		Based on $108/MWh[8]		Based on $34.26/Ton Coal[9]	Based on $1/100Gal[10]					Based on JEDI[11]	Based on JEDI[11]			
Solar Thermal	Generation MW	Generation Cost $/MWYr	Total Production Cost $/Yr	Fuel Savings $/Yr	Water Savings $/Yr	Ash Reduction Tons/Yr	Avoided Sox Emissions Tons/Yr	Avoided NOx Emissions Tons/Yr	Avoided CO2 Emissions Tons/Yr	Jobs Created Construction and O&M	Jobs Value to County $/yr	Net Adjusted Production Costs $/Yr	Initial Assumed Cost Cents/kWh	Adjusted Assumed Cost Cents/kWh
	500	1,471,680	735,840,000	36,014,112	$0	125,000	34,605	57,294	4,432,560	20,145	84,097,992	615,727,896	16.8	14.1
		Based on $168/MWh[8]								Based on SAM[12]	Based on SAM[12]			

1. Cholla Power Plant Average Total Cost of Generation; 2. Controlling Power Plant CO2 Emissions: netl.doe.gov; 3. Energy Citations: osti.gov; 4. PFBC: worldbank.org; 5. Responsibility Report: Pinnacle Corporation; 6. Renewing Arizona's Economy: PIRG Education Fund; 7. CCS: fossil.energy.gov; 8. AZ Renewable Energy Assessment: Black and Veatch; 9. World Price Index, 2007; 10. Residential Water Bill: April, 2008; 11. Jobs and Economic Impact Model: National Renewable Energy Laboratory; 12. Solar Advisor Model: National Renewable Energy Laboratory. Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California: Black & Veatach

Slide 12



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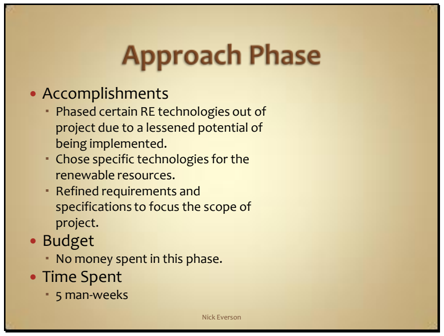

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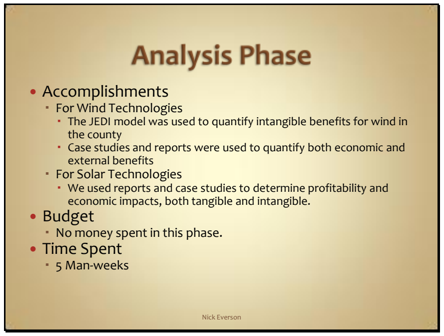

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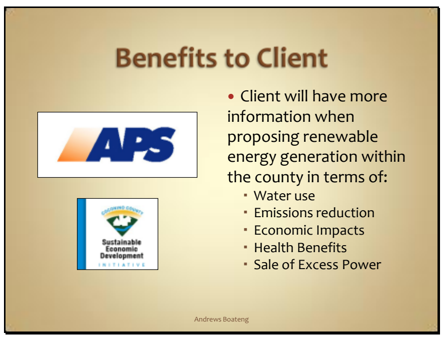

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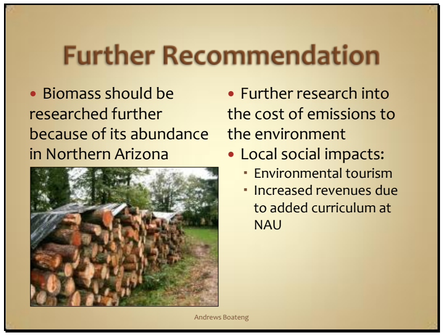

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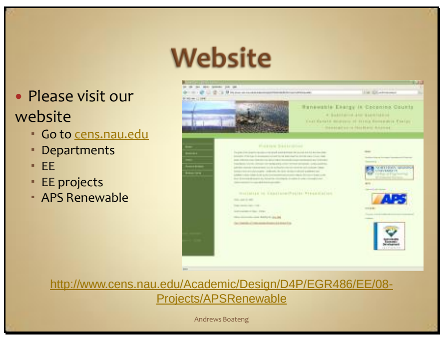

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