Breakin' Wind in Sub Saharan Africa

ES 2501 - 3D particle equilibrium project

Currently 2 out of 3 people in sub Saharan Africa lack access to electricity.[1] Adding electricity to a community will save people from house fires associated with using candle light, add medical infrastructure to help fight sickness and disease, improve access to education, power water filtration systems, and will provide many other benefits.

One method of brining power to remote locations is through the use of disperse wind power systems. A hot air balloon wind turbine by Altaeros Energies could be installed in a remote community and provide the electricity to meet some or all of the communities requirements. To anchor the turbine in this community, you and your team need to design a cable system that holds the turbine in a given spot shown on the map with a star. The balloon will provide a force of $\mathbf{F_b}$={75**i** + 220**j** +1000**k**}N based on lift and wind. Three cables will be used to hold the balloon in place (equilibrium). The cables can support a maximum tension of 2000 N. The maximum balloon altitude is 600 meters.

The village would like to use some of the power for local use and then sell the remaining power to near by villages in order to recoup the initial purchase cost of the system. You will need to do some brainstorming and research to determine what the village will want to power. This will give you a sense of how much energy they need to generate and how much they will be able to sell. Be sure to keep track of all of your references, as you will be submitting a bibliography with your project.

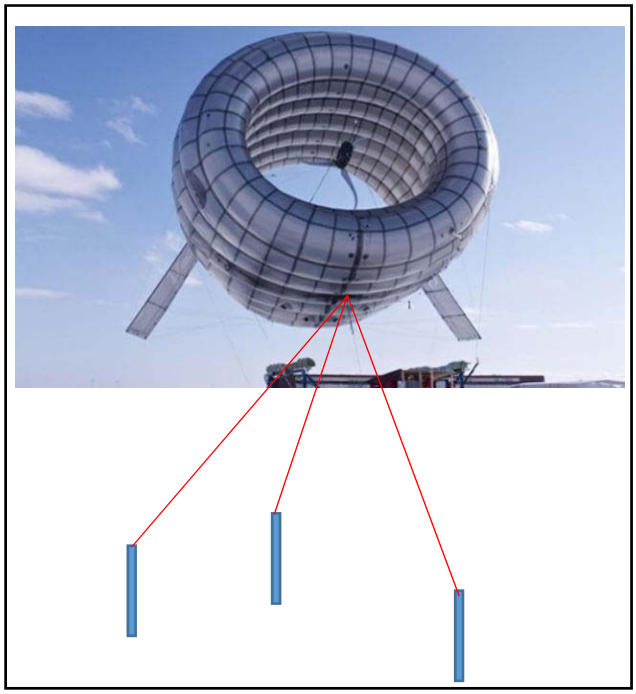
You and your team need to determine the payback time, in years, for the community so they can decide if they should purchase the turbine. Payback time = total cost of materials (cables + balloon) and construction based on the locations chosen divided by the power generation revenue from power sold to neighboring communities.

Balloon Cost: $175,000

Cable Cost: $125/meter

Power generation revenue for power sold to neighboring communities: $0.11/kWh

Power generated versus altitude: 100 W/meter of altitude (note this linear relationship is a very loose, first order, approximation of actual wind phenomena.)



[1] https://www.usaid.gov/powerafrica

Teams:

Teams of 2-3 will be assigned for this project. Every student should have a chance to work on or review all aspects of the project including vector analysis, payback time calculations, and writing/poster making.

Project Deliverables:

For this project, you and your teammates will determine two cable anchoring configurations and calculate the payback time based on your choices as well as the social impact score.

1) Calculations (neatly by hand or typed) that:
    a. demonstrate that the cable configurations meets the required criteria
    b. detail payback time based on the power generated, amount used by the community, and amount sold to the neighboring community
    c. determine social impact score
    d. Note: all power requirements and power use references should be cited within the calculations and a bibliography should be included at the end of your calculations. You may use whatever standard citations style you would like, but you must be consistent for all your sources.
2) Your team will make a digital **marketing** poster, either 3'x4' or 4'x3', (using PowerPoint or similar) showing your chosen configuration. The poster should make clear why this configuration would be beneficial for the community. It should clearly detail what you will power in their community as well as how much power you will sell. You are using this poster to try and **sell your idea**, so it should look polished and persuasive.
3) Each team will write a persuasive paper 1-2 pages in length to demonstrate to the community and potential investors the benefits of your top choice cable configuration. (i.e. pick one of your two configurations and argue why it should be implemented over your other configuration.) You should discuss the payback time, social impact, and the proposed things your group intends to power within the community. You want to tell the community what they will be getting out of your proposed system. While you do not have social impact scores for each of the things that your group decides to power, you should explain to the community why the things you have proposed to power within the village will be beneficial to them, and possibly why these outweigh or address some of the negative social impact scores that you incurred during construction.
4) QC deliverable

Project Submission

- The first three project deliverables are due by midnight on **Wednesday 9/13/2017**. One team member will upload your poster, calculations, and persuasive paper as .pdf files. Be sure to check that the conversion to .pdf was successful and that you can zoom into locations on your posters to read/view content. ALL team member names must be on all documents submitted. You must also send your documents to your reviewing team via CANVAS messenger. See the QC section below for your trading team.

- The QC deliverable is due by midnight on **Monday 9/18/2017**. The QC will be given to the reviewed team via CANVAS messenger AND will be submitted on CANVAS as an assignment. Extra credit grading assignment is due with this QC deliverable.
- Once you receive your QC, you may make any changes that you wish. Your final submission is due on **Wednesday 9/20/2017** by midnight. This final submission will include all **four** deliverables as .pdf files. You must submit the QC that your team completed of the another team's project.

Zones:

Blank Regions = No Construction in these zones.

You cannot build on the beach or in the dense vegetation as the anchors will not hold in the sand and the vegetation will tangle the cables.

1: There are small gas pockets in this region. There is a 5% chance that while drilling for the anchor that a gas pocket could be breached. If breached, there would be a $150,000 clean-up cost. However, if a gas pocket is not breached, there is a construction cost of $5,000. If you pick this location, you will have to pay a $50,000 deposit in to begin to cover costs in the event you hit a gas pocket. You must justify this deposit and additional risk to your investors. Building at the site incurs a social impact score of -4 for putting the community at potentially elevated risks.

2: In this zone, there is a rhinoceros migration route. There is a low financial cost for construction in this zone, however you will be intruding on the migration route.

3: The community is planning on building a school in this zone. There is an alternate school location in zone 8. If you anchor a cable in zone 3, and the school is placed in zone 8, then 1 in 500 students will not be able to attend school due to the effects of the noxious gasses.

4: In this zone, there are no construction costs as there is a government subsidy to build in this area. However, there is a 10% chance that you will encounter a religious burial ground at this zone. If you build here, you will have to pay $5,000 to relocate the remains and you will incur a -6 social score.

5: This zone is swampy lands. Development of this site would release 20 kTonnes of CO_2.

6: This zone is privately owned land. You must pay the land owner for land use. By developing this land, the owner will be able to use the money to start a local business that will employ 2 community members.

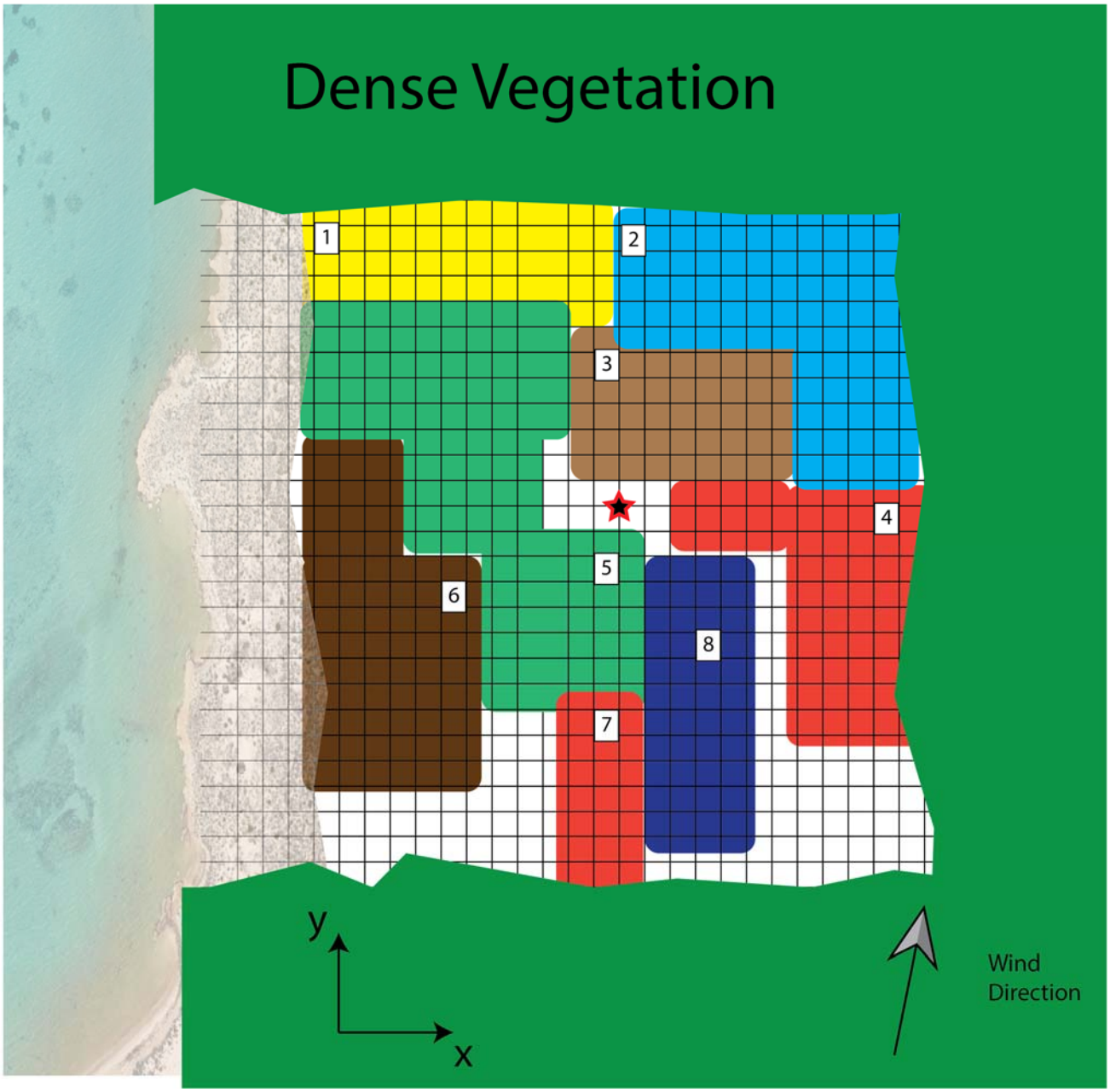
7: This zone is a swampy region that has an infestation of mosquitoes. Construction on this land would reduce the mosquito population and help reduce disease in the region.

8: This zone would provide an alternative school site. Either zone 8 or zone 3 must be left undeveloped for the school.

Zone Metrics:

Zone	Construction Cost	Social Impact Score
1	$50,000	-4
2	$2,500	-3
3	$4,000	-4
4	$5,000	-6
5	$10,000	-4
6	$120,000	+8
7	$10,000	+4
8	$5,000	0

Site Map



Each grid spacing is equal to: 10 meters.

Rubric

Category	Exceeds Expectations (95% ±5%)	Meets Expectations (85%±5%)	Acceptable (75%±5%)	Needs Improvement (50%±25%)
Cable Length Calculations (15 points)	No errors are made in the cable length calculations.	There is 1 error made in the cable length calculations.	There are 2 errors made in the cable length calculations.	There are more than 2 errors made in the cable length calculations.
Cable Tension Calculations Setup (10 points)	A correct FBD is shown with all labels and information necessary to solve for the cable tensions.	A correct FBD is shown with all but 1 missing element such as a label or other necessary information needed to solve for the cable tensions.	A correct FBD is shown with all but 2 missing element such as a label or other necessary information needed to solve for the cable tensions.	A FBD is shown either incorrectly or with more than 2 missing elements needed to solve for the cable tensions.
Cable Tension Calculations Execution (15 points)	All cable tension calculations are correct	There is 1 minor error such as a calculator error, sign error, or units error in the calculations of the cable tensions	There are 2 minor errors such as a calculator error, sign error, or units error in the calculations of the cable tensions. Or there is 1 major error such as incorrect positon vectors or force vectors.	There are 3 or more minor errors such as a calculator error, sign error, or units error in the calculations of the cable tensions. Or there are two or more major errors such as incorrect positon vectors or force vectors.
Anchor Location Selection (10 points)	All anchor points are selected such that there are no “negative” tension values.			1 or 2 of the anchor point locations are such that the applied wind load results in a “negative” tension.
Payback Calculations (10 points)	No errors are made in the payback time calculations. Power consumption for the village is justified and thorough. You have at least 5 components that you have scoped to power within the	There is 1 error in the payback time calculations. Power consumption for the village is justified and thorough. You have at least 4 components that you have scoped to power within the	There are 2 errors in the payback time calculations. Power consumption for the village is justified but research to back up power consumption claims is limited. You have at least 3 components that	There are more than 2 errors in the payback time calculations. Power consumption for the village may be off and research to back up power consumption claims is limited or incorrect. You have

	village. The sources used to determine consumption are credible.	village. The sources used to determine consumption are credible.	you have scoped to power within the village. The sources used to determine consumption are credible.	at least 2 components that you have scoped to power within the village. The sources used to determine consumption are mostly credible.
Poster Presentation (15 points)	The poster design is clean and polished. There is not an over abundance of cluttered and/or small text. There is a persuasive tone to the poster as it is clearly marketing one of the two anchoring designs shown.	The poster design is clean and mostly polished. There may be too much small text or not enough text to explain the design. There is clearly one anchoring design that is chosen, but the marketing is not persuasive.	The poster design is not polished. There is either too much text such that the poster looks busy or not enough to explain the design. There are two anchoring designs shown, but it is not clear that one was chosen by the group to market to the community.	The poster design is difficult to follow. The anchoring designs are unclear or only one is shown.
Persuasive Paper (10 points)	Arguments for one of the two designs are clear, logical, and convincing. The following are thoroughly discussed: 1) The social impact of the construction zones as well as the proposed systems in the community to be powered and their relative merits 2) The balancing of powering local systems and selling power to nearby communities	Arguments for one of the two designs are clear, logical, and convincing. The social impact of the construction zones as well as the proposed systems in the community to be powered are discussed however, the relative importance of each social factor is not clear. The balancing of powering local systems and selling power to nearby communities is discussed, but the importance of this balance may not be completely clear.	Arguments for one of the two designs are clear, logical, and convincing. The social impact of the construction zones is discussed but little is mentioned about the social factors addressed by the proposed systems that would be powered by the turbine. The balancing of powering local systems and selling power to nearby communities is unclear or minimally mentioned.	Arguments for one of the two designs are made, but are not completely clear or logical. The social impact of the construction zones is minimally discussed and discussion about other social factors is limited. The balancing of powering local systems and selling power to nearby communities is very unclear or not mentioned.
QC (15 points)	SEE BELOW FOR DETAILS			

ES 2501 Balloon Group Project Calculations Review

You will be trading your calculations with another team to review their calculations. This type of quality control (QC) process is common in engineering practice as work must be reviewed before being delivered to your clients.

You will send all of your submitted work to your reviewer group and they should send their work back to you. You will be sending your work to the Balloon Project groups as shown in the reviewing table below.

1↔2	11↔12	21↔22
3↔4	13↔14	23↔24
5↔6	15↔16	25↔26
7↔8	17↔18	27↔28
9↔10	19↔20	29↔30

Schedule:

- The project is due on 9/13/2016 at midnight.
- Send your work to the reviewing team when you submit the project. This is done via CANVAS messenger. A video is uploaded to the Projects page to explain this process.
- Review the work that you received from the other team.
- Submit the reviewed work to CANVAS by Monday 9/18/2016 by midnight. When you submit, you must also send your review back to the team you reviewed via CANVAS messanger.
- Review your work based on the corrections you received.
- Resubmit your project along with a copy of the corrections that your team did of the other teams work by Wednesday 9/20/2016 at midnight.
- If a resubmission is not received by midnight on 9/20/2016, the original submission will be used for your final project grade.

Reviewing:

You will be reviewing the other teams work using the provided rubric that will be used for final grading. Each of the rubric categories (other than QC) should be addressed in your review.

As there are two different configurations that were calculated by each team, at least one person from each team should review each configuration. You may want to do a detailed review of one of the configurations and then trade with someone in your team to do a quick review of the configuration that they reviewed in detail. You will be reviewing both the statics calculations and the payback time calculations. Your calculations review must include source checking for source quality and data correctness.

You will be providing written feedback to the team whose work you are checking. This can be in the form of a report, as a scan of hand written notes on a copy of their calculations, or some other method that you choose. This must be legible feedback so that they will be able to make the appropriate corrections. You should have at least ½ page written to summarize your groups' feedback. This should highlight both strengths and weaknesses of their work as well as summarize your overall impression.

You should focus your corrections on constructive feedback that will help the other group improve their final product. You should be giving input to both their calculations and their report. However, this does NOT mean that you are to edit their writing. You will be checking the report of sound logic and analysis/evaluation of calculations. (i.e. does the report convey sound conclusions about the cable scenarios described?)

QC Points Rubric

	5 pts	**3 pts**	**1 pts**	**0 pts**
Errors Identification (5 points on main rubric)	All calculation errors were found	1 calculation error was not identified	2 calculation errors were not identified	3 or more calculation errors were not identified
Clear and Legible Feedback (5 points on main rubric)	The root cause of the error is identified, and the change required to correct this action is shown. Corrective actions have clear feedback.	The root cause is not always identified, but changes are shown. Corrective actions have clear feedback.	Corrective actions are not clear, some changes are unclear or incorrect	Incorrect changes/corrections are given. Feedback is unclear/not decipherable.
Source Checking (5 points on main rubric)	All sources have been checked for credibility and your check of the sources is communicated to the other team clearly.	All sources have been checked for credibility but your source check communication to the other team is somewhat unclear.	Most sources have been checked and your source check communication to the other team is somewhat unclear.	Sources were not checked or the source checking was not communicated to the other team.

Source Credibility: Check out the Gordon Library's Evaluating Information video to help you in your evaluation of their sources. http://libguides.wpi.edu/ch1030/thinkingaboutinformation

Extra Credit QC grading – up to 5 extra credit points

Grade the other teams project based on the main rubric (Not including the QC section). You must find concrete examples for why their work would fall into each of the rubric categories that you select. This extra credit submission should include the rubric with the circled graded category AND the evidence (screenshots and underlined/highlighted areas or explanations) must both be submitted digitally.