CAPSTONE/SENIOR DESIGN EXPERIENCE 2016

Title: Haitian Power Project II

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Agricultural & Biological ENGINEERING

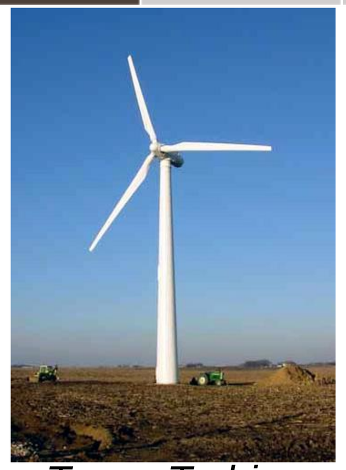
Background & Problem Statement:

The Village of Hope is a school in Haiti sponsored by American missionaries, which also functions as a clinic and a food distributor. Their campus is looking to expand, adding on-site residences and an industrial-size kitchen.

Without access to a reliable power grid, the Village of Hope powers its well, lights, medical equipment, amenities and utilities using electricity generated on-site by a 13.5 kW generator running near-continuously. The administrators are concerned by the heavy financial and environmental costs of this generator, and have decided to explore substitutes and supplements which will make use of the local abundance of wind and sunshine. A small array of solar panels has been installed on the campus, and this team will be assessing whether wind power will be a viable addition to their personal power grid.

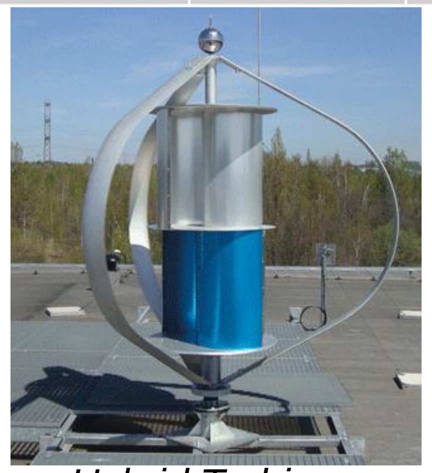
Alternative Solutions: Selection by Decision Matrix

Type of Turbine	Directionality (3)		Tip-Speed Ratio (4)		Torque (2)		Cost (3)		Total
	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted	Weighted
Tower HAWT	1	3	4	16	2	4	2	6	29
Savonius	4	12	1	4	3	6	2	6	28
Darrieus	4	12	3	12	1	2	2	6	32
Hybrid	**4**	**12**	**3**	**12**	**3**	**6**	**1**	**3**	**33**

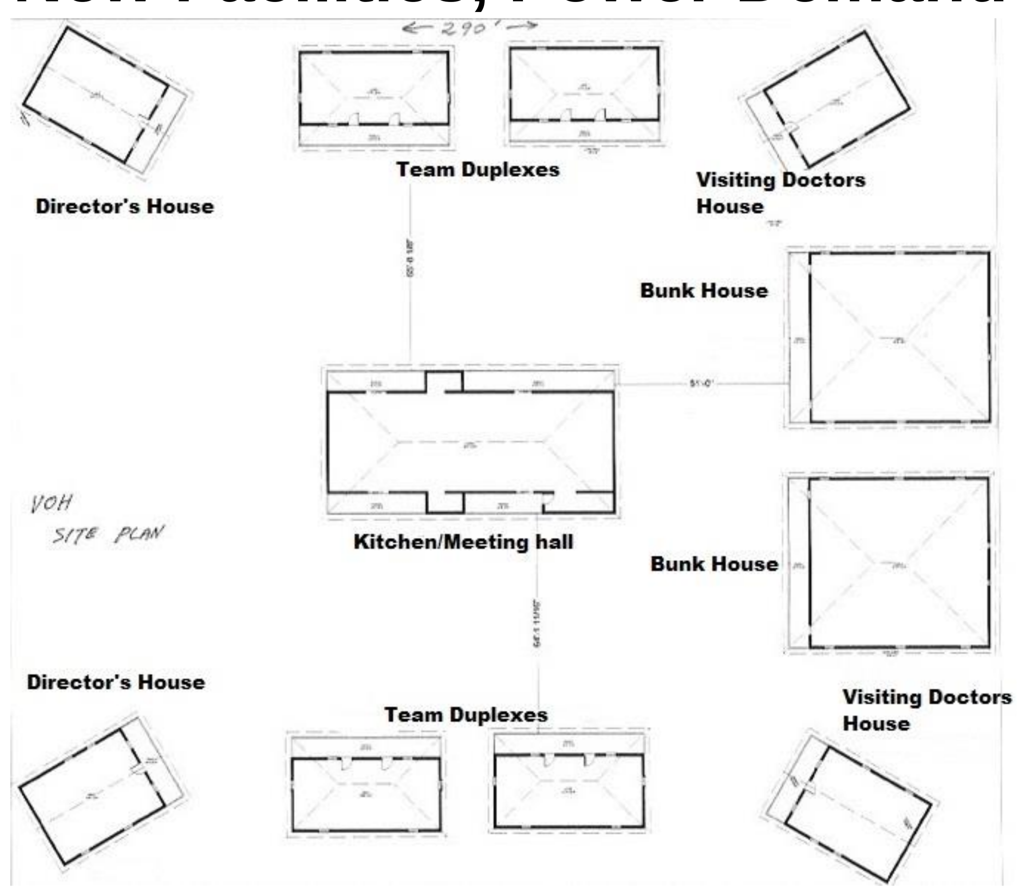

Tower Turbine


Savonius Turbine

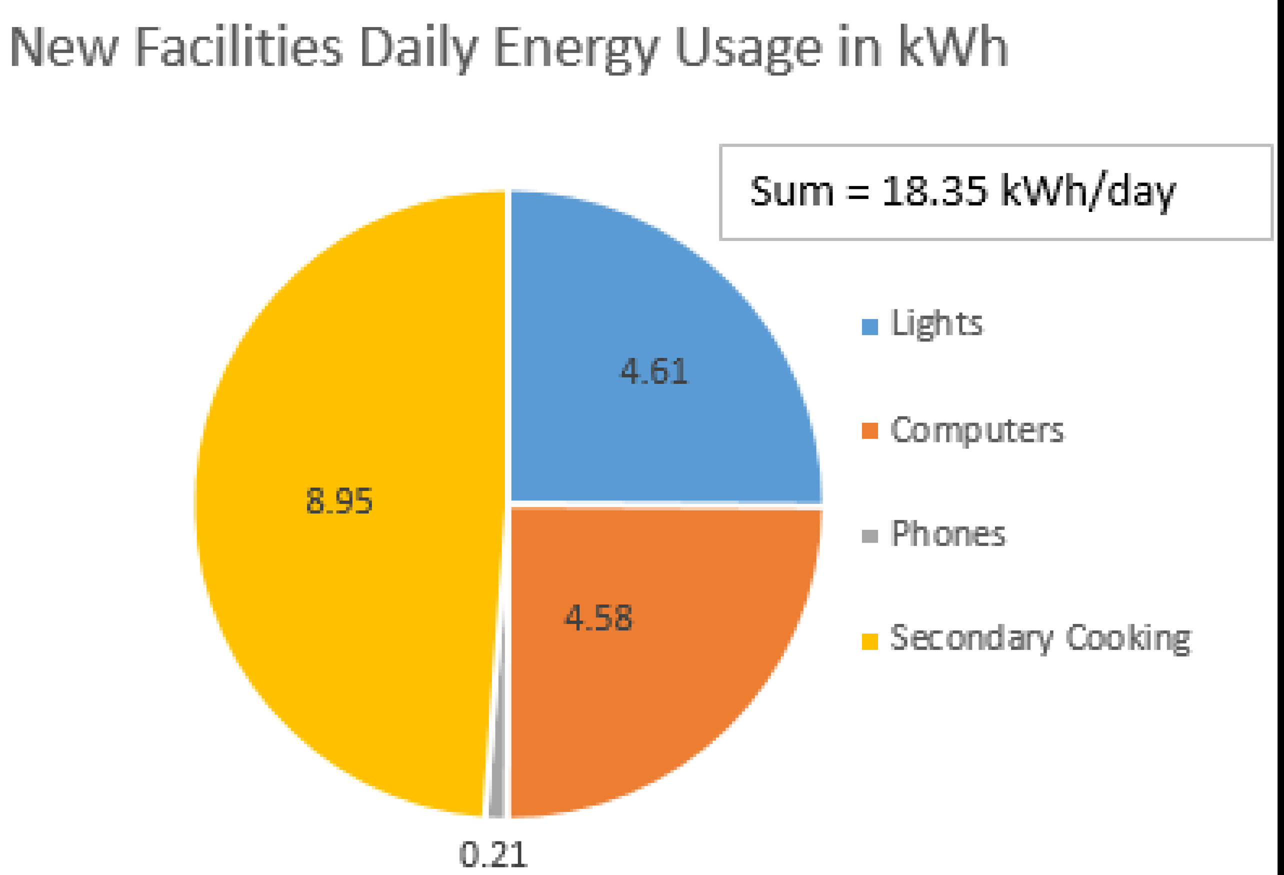

Darrieus Turbine


Hybrid Turbine

New Facilities, Power Demand Estimations:

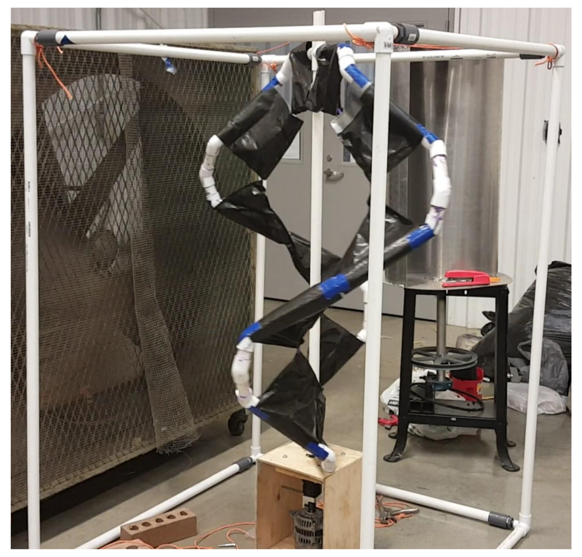


VoH New Facilities Plan



New Facilities Power Demand

Solution Evaluation:


Haitian Hybrid, Darrieus


Haitian Hybrid, Savonius

Based on the advantages suggested by the Decision Matrix, The team designed a hybrid turbine that would make use of the relative strengths of two vertical axis turbines, the Darrieus and the Savonius. The Savonius would overcome initial resistance, and the Darrieus permit high maximum speeds. In theory, both rotors would share a shaft, which would be supported by a PVC frame, and connected to an alternator (1800 rpm operating speed) via a 10:1 gear box.

Due to testing limitations, The team decided to craft both rotors to fit within a 4ft x 4ft x 6ft space, and test their speeds separately to gain quantitative results. The assembly itself was designed to be manufactured primarily using materials available in Haiti.

The Darrieus airfoils were constructed from a tarp sleeve, pulled taut between a PVC guide and wire. Each guide was initially designed to be a half-circle of heated and shaped 1” PVC pipe, twisted to provide the necessary angle of attack to generate lift, but the team eventually redesigned this in favor of an octagonal guide connected by PVC elbows.

The Savonius turbine was constructed by vertically bisecting a HDPE 55 gallon drum and bolting it to the shaft. A metal bar was added to prevent the turbine from sagging under its own weight, and holes were drilled through the back to allow smoother rotation.

Qualitative testing was conducted using a box fan generating estimated wind speeds between 10-15 mph (the expected average wind speed at the VoH site falls within this range). The team determined that, while the loaded Savonius rotor was able to generate rotation speeds exceeding 15 rpm while unloaded, the Darrieus rotor, even unloaded was unable to maintain continuous rotation, and would be unable to actuate the alternator and produce electricity.

Budget:

Labor		
Component	Duration	Units
Frame	0.25	Man-Hours
Shaft	0.25	Man Hours
Box w/bearing housing	1	Man-Hours
Darrieus	20	Man Hours
Savonius	3	Man-Hours
Total	**24.5**	Man Hours

Budget, Labor

The financial cost appears to be dominated by the planetary gear box, which had to be ordered from an online vendor. A v-belt power train with additional supports could allow consistent power transfer, at greatly reduced cost.

Materials			
Item	#	Unit Price $	Total Price $
1/4" x 2" hex bolt	6	0.13	0.79
1" x 1/2" bush PVC	1	1.74	1.74
1/4" flat washer	18	0.06	0.99
1/4" wing nut	20	0.04	0.89
1/4" x 1-1/2" hex bolt	7	0.11	0.79
1" x 3/4" insert	2	0.48	0.96
48" Bungee cords	4	1.78	7.12
1" PVC elbow	20	0.97	19.4
3/4" insert x 1/2" adapt	1	0.94	0.94
1-1/4" x 1" insert couple	2	0.73	1.46
8' x 10' tarp	1	7.96	7.96
5/32", 50' rope	1	4.39	4.39
PVC cleaner	1	7.49	7.49
PVC cement/primer	1	7.99	7.99
PVC cross 1"	4	3.29	13.16
10' PVC 1"	4	2.83	11.32
5' PVC 1"	13	2.27	29.51
Compact tractor alternator	1	74.65	74.65
HDP 55 gal barrel*	1	69.99	69.99
Plywood 4' by 8', 1/2" *	1	25.99	25.99
Subtotal			**191.55**
10:1 planetary gear box	1	419.0	419.0
Total			**610.55**

Budget, Materials

Social Impact:

- Unsuccessful at generating electricity with this design, although could provide suggestions for an improved future project, with a slower alternator, stiffer, better shaped airfoils, and a supported V-Belt power train.
- Analytics of campus energy demand can be used to predict future energy supply parameters at Village of Hope
- Analysis suggests that the current energy production (~277 kWh, on average) at the Village of Hope likely vastly exceeds their true energy needs, and that much of their current costs can be saved by more conservative behaviors.

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