Midterm Presentation

The Last Airbenders

MAE 189: Project 13

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Mission Statement

- Homes in remote areas need a clean, reliable backup source of electricity in case of a power outage
- Available wind turbines on the market are difficult to install and perform maintenance without professional help

Overview

This project aims to design and plan the manufacturing of a small-scale wind turbine for farms and remote homes, designed for a single family's emergency use.

Shiming Xu

Objectives

- Produce enough power to run appliances needed in emergency situations
- Needs to be able to be set up by at most 2 people
- Needs to be durable (withstand high wind speeds)
  - Safety systems to prevent any hazards
- Should be easy to assemble and repair
- Needs to be affordable



Tom

Design Attributes & Requirements

Design Attribute Table:

Attribute	O	C	F	M
Must be safe				
Must be reliable				
Must be easily manufactured				
Must be easily assembled by 1 or 2 people				
Could use a vertical blade				
Must be able to power/charge groups of standard devices/appliances in remote home				
Could be roof-mounted				
Should be reasonably inexpensive (≤$1000)				
Must be reasonably lightweight (~25 lbs)				
Must have safety features				
Could use energy storage system (e.g. battery)				

Requirements/Metrics Table

	Component	Need or Objective	Importance (5=most important)
1	The generator	is able to charge household devices	5
2	The wind turbine	is reasonably priced	4
3	The wind turbine	is durable	3
4	The wind turbine	is lightweight	3
5	The entire assembly	is safe	5
6	The wind turbine	is easy to assemble	3
7	The wind turbine	is easy to manufacture	4
8	The wind turbine	is able to withstand high winds	5
9	The battery	is reasonably sized for needs	5

*importance ranking: 5=most important, 1=least important

Elaine

Problem Definition

Design Constraints

- Average of wind speed (California) = 14.86mph = 6.64m/s (market survey-charging)
- Price Range: less than $800 total

Design Requirements

- Needs to be able to be assembled by at most 2 adults
    - max height: 2 meters, max weight: 25 lbs per component
- Generate enough electricity for emergency
    - Operational Case 1: 300 watts
- Needs to be durable (withstand high wind speeds)

Jeremiah

Problem Definition

1. 1814 city's wind speed (California)

1	6.33	Santa Barbara, CA / 89,669	AVERAGE	14.86mph=6.64m/s
2	6.36	Lemon Grove, CA / 25,963		
3	6.37	National City, CA / 59,543		
4	6.43	Cardiff By The Sea, CA		
5	6.45	Lincoln Acres, CA		
6	6.59	La Presa, CA / 34,739		

2. Price

Market Survey Wind Turbine

name	price ($)
LISHUN-1000	340
LISHUN-1500	633
LISHUN-2000	730
LISHUN-2500	1200
LISHUN-3000	1466

Price of Generator Candidates

Model	Price ($)
IRFORA	167.88/167.99
NE-200	$151.39
AVAN-300W	$184.19
AVAN-300W	$161.64
FreeEnergy 1200W	$159

3. Power Output

	Situation Description	Devices	Time (hrs)	Total Energy (KJ)
Operational Case 1	night (temperature low)	• Lightbulbs (50w) • Phones (10w) • Heater (1000w) • Radio (1.5w)	• Lightbulbs (3hrs) • Phones (1hr) • Heater (3hr) • Radio (12hrs)	• Lightbulbs (540 KJ) • Phones (36 KJ) • Heater (10800 KJ) • Radio (64.8 KJ) Total: 11,140.8 KJ
Operational Case 2	Day time (summer/ warm climate)	• Phones (10w) • Radio (1.5w)	• Phones (1hr) • Radio (12hrs)	• Phones (36 KJ) • Radio (64.8KJ) Total: 100.8 KJ
Operational Case 3	Day time (winter/ cold climate)	• Phones (10w) • Radio (1.5w) • Heater (1000w)	• Phones (1hr) • Radio (12hrs) • Heater (2hrs)	7300.8kJ • Phone (36 KJ) • Radio (64.8 KJ) • Heater (7200 KJ) Total: 7300.8 KJ

11140.8 KJ/ 43200 s = 0.258 kW to charge the battery within 12 hours
0.129 kW to charge the battery within 24 hours

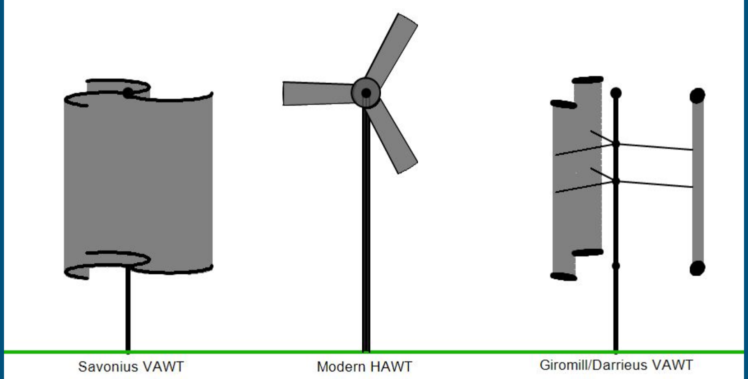
For Operational Case 1, all devices run for 3 hours.
540+36+10800+16.2=11392.2KJ
11392.2/(3*60*60)=1.0548 kw

Jeremiah

Conceptual Design: Comparison

<u>Horizontal Axis Wind Turbine</u>

- Higher velocity → more power
- More efficient
- Less turbulent wind flow → Less vibration
- More reliable



<u>Vertical Axis Wind Turbine</u>

- Cheaper to produce
- Easy to install/repair → lower height
- Easy to transport
- Low speed blades → less risk to birds
- Functions in extreme weather (variable winds)
- Less noise
- Easy to scale down size

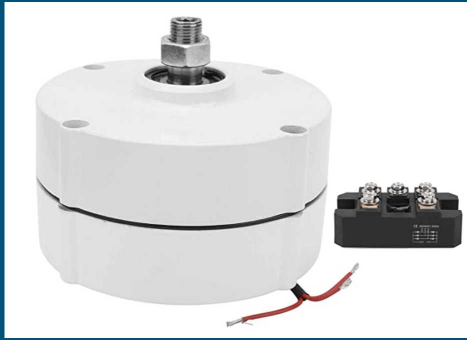
Adam

Proposed Design: SWOT Analysis

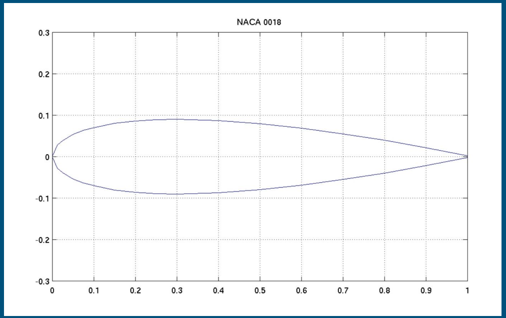
- H-Darrieus vertical-axis wind turbine
  - Strengths
    - Fairly efficient (30–40%)
    - Scales down
    - More easily maintained
    - Safe / easy to install
  - Weaknesses
    - Lower power output than HAWT
    - Less efficient than HAWT (40–50%)
  - Opportunities
    - Good fit for market niche (emergency preparedness)
    - Cheap to produce / output
  - Threats
    - Consumers may not want to pay price

Adam

Proposed Design



- Design:
  - H-Darrieus vertical-axis wind turbine
    - 30–40% efficiency
    - Translates well to small scale
    - Easy to install / maintain
  - 300W 3-phase PMA
    - Lower-end RPM (600)
    - Lightweight (~8 lbs / 3.6 kg)
    - Desirable power output
    - Includes rectifier circuit



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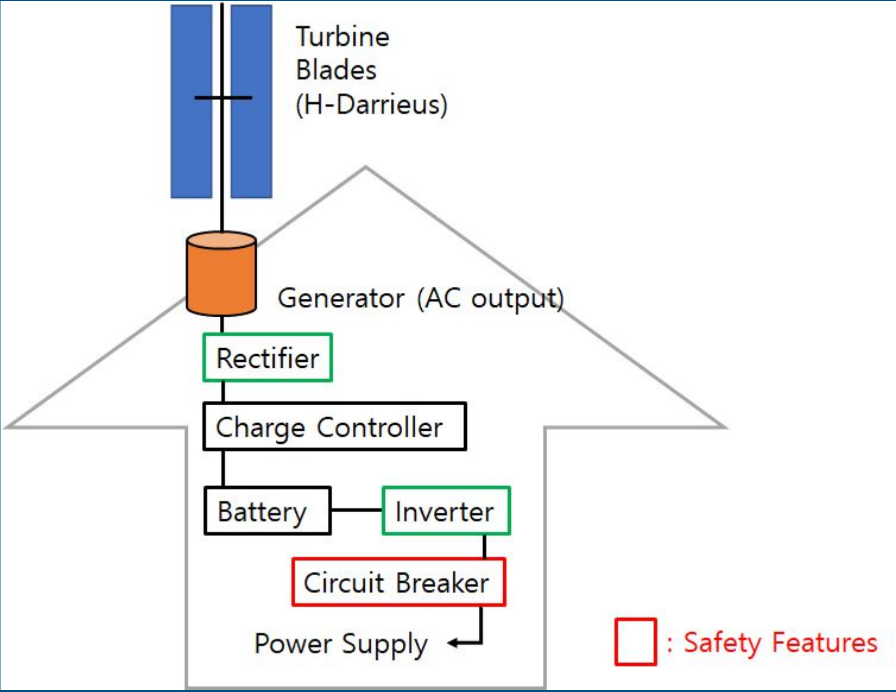
Assembly Schematic & Safety Features

- Remaining design decisions:
  - How wind turbine connects to devices/appliances within a house
  - Possible backup battery system



Tom

Key Design Decisions and Justifications

- Process:
  - Power requirements
  - PMA selection
  - HAWT vs. VAWT comparison

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Key Design Decisions and Justifications

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Option #	Model	Price ($)	Rated Power (W)	Voltage (Volts)	Rated Speed (RPM)	Weight (lbs)	Dimensions
1	IRFORA	167.88/167.99	300	12/24	750	11.02	8.27in x 8.27in x 8.27in
2	NE-200	$151.39	200	12	1100	7.26	
3	AVAN-300W	$184.19	300	48	600	7.94	Height = 70mm, Diameter =150mm
4	AVAN-300W	$161.64	300	48	600	not specified	70mm / 2.8in, 81mm / 3.2in
5	FreeEnergy 1200W	$159	1200	12/24/48 DC	not specified	11.125	Diameter:10.7cm, Length:14.85cm

Adam

Finalized Dimension:

NACA 0018 Airfoil

Diameter: 2.25m

Height: 1.58m

Chord Length: 0.224m

Turbine Blades Number: 2

Resulted RPM under wind speed of 6.64m/s: 170RPM

Shiming

Major Components Table

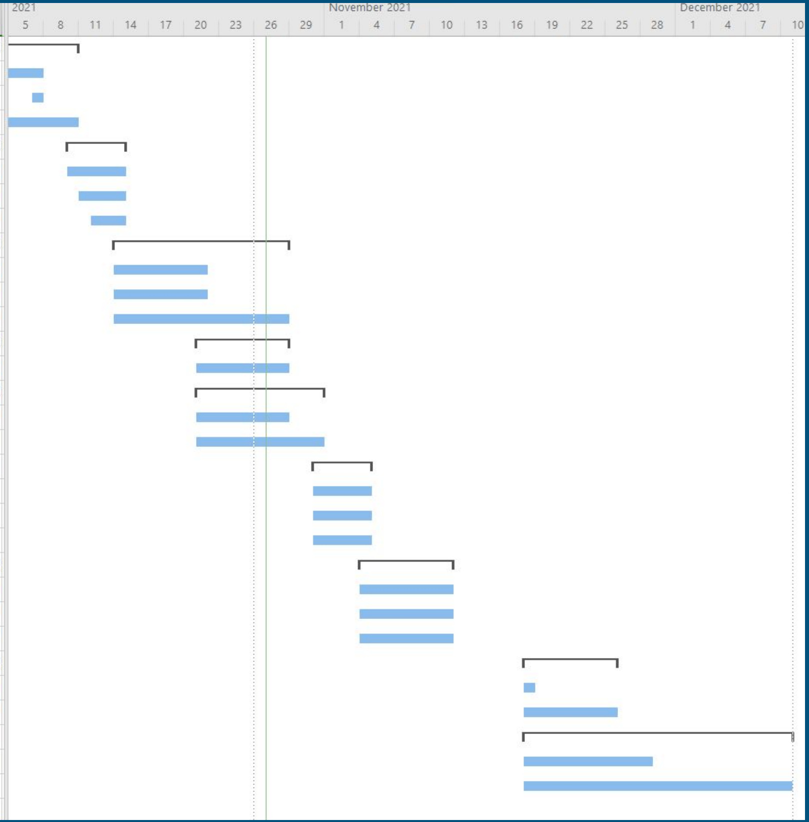
Components	Purchased/ Machined	Description	Product Link
Generator	Purchased	AVAN-300W : Rated Power 300w, Rated wind speed 600 RPM, voltage 48v PS. it will be modified after optimization analysis	https://www.amazon.com/AVAN-300W-Three-Phase-alternator-Permanent-Generator/dp/B08MZG48CM
Blades	Machined	n/a	n/a
Battery	Purchased	n/a	n/a
Gear Box	Purchased	n/a	n/a

Jeremiah

Project Schedule

GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish
1		**Team formation and scope**	**7 days**	**Sat 10/2/21**	**Sun 10/10/21**
2		Research how wind turbines operate and current designs on the market	5 days	Sat 10/2/21	Thu 10/7/21
3		Meeting with client	1 day	Thu 10/7/21	Thu 10/7/21
4		Draft organizational chart and team contract	6 days	Mon 10/4/21	Sun 10/10/21
5		**Quantifying mission statement**	**5 days**	**Sun 10/10/21**	**Thu 10/14/21**
6		Assign requirements based on estimated needs	5 days	Sun 10/10/21	Thu 10/14/21
7		Quantify energy needs	4 days	Mon 10/11/21	Thu 10/14/21
8		Conduct situational analysis	3 days	Tue 10/12/21	Thu 10/14/21
9		**Preliminary design**	**11 days**	**Thu 10/14/21**	**Thu 10/28/21**
10		Create 3 preliminary wind turbine designs and explore attributes	6 days	Thu 10/14/21	Thu 10/21/21
11		Select one design based on needs & constraints	6 days	Thu 10/14/21	Thu 10/21/21
12		Draw schematic of selected design	11 days	Thu 10/14/21	Thu 10/28/21
13		**Optimization**	**6 days**	**Thu 10/21/21**	**Thu 10/28/21**
14		Optimize wind turbine specifications based on needs & constraints	6 days	Thu 10/21/21	Thu 10/28/21
15		**Midterm Presentation**	**8 days**	**Thu 10/21/21**	**Sun 10/31/21**
16		Create powerpoint presentation	6 days	Thu 10/21/21	Thu 10/28/21
17		Write report segments on sections completed	8 days	Thu 10/21/21	Sun 10/31/21
18		**Create models**	**5 days**	**Sun 10/31/21**	**Thu 11/4/21**
19		Create 3D SolidWorks model of parts	5 days	Sun 10/31/21	Thu 11/4/21
20		Conduct SolidWorks simulation testing	5 days	Sun 10/31/21	Thu 11/4/21
21		Create electrical model	5 days	Sun 10/31/21	Thu 11/4/21
22		**Manufacturing plan**	**6 days**	**Thu 11/4/21**	**Thu 11/11/21**
23		Compile components/parts orders	6 days	Thu 11/4/21	Thu 11/11/21
24		Create design drawings from Solidworks	6 days	Thu 11/4/21	Thu 11/11/21
25		Finalize files for 3D printing	6 days	Thu 11/4/21	Thu 11/11/21
26		**Review Design**	**6 days**	**Thu 11/18/21**	**Thu 11/25/21**
27		Meeting with client	1 day	Thu 11/18/21	Thu 11/18/21
28		Adjustments to design, if need	6 days	Thu 11/18/21	Thu 11/25/21
29		**Final Presentation**	**18 days**	**Thu 11/18/21**	**Fri 12/10/21**
30		Create PowerPoint presentation	8 days	Thu 11/18/21	Sun 11/28/21
31		Finalize final report	18 days	Thu 11/18/21	Fri 12/10/21



Elaine

Detailed schedule with task assignments for the rest of the quarter.

Detailed schedule:

- Week 6 & 7:

  1. Detailing the design by building the 3D model (Solidworks) and electrical mode based on the dimension from calculations.

  2. Testing the design with the Solidwork simulation (No manufacturing will be done in this quarter, thus only simulation with software will be available)

  3. Planning of the manufacturing phase.

- Week 8:

  1.Hold a design review meeting with the team and the sponsor and adjust design as needed

- Week 9:

  1.Finalize presentation and design report for UCI's MAE 189 capstone design meeting.

Shiming

List any other resources and questions/concerns that need to be resolved

- Guidance in optimization analysis (Power Output vs RPM with fixed Height/Diameter, Efficiency vs RPM with fixed Height/Diameter)

- Guidance in measuring losses (Mechanical losses of the blades, Electrical losses of the turbine)

Jeremiah

Thank You!

Questions?