Spring 2014

Team SOLAREADY

Northern Arizona University

Department of Mechanical Engineering:

Solar Tracking Structure

The Team

Presenters

Dan Verne (ME)

Angelo Edge (ME)

Hashem Bukhamsin (ME)

Roger Guiel (ME)

Other Members

Curt DuRocher (EE)
Dustin Sagg (EE)
Michael Helland (EE)
M. Ian Farnsworth
Majad Alharbi (EE)

Overview

- Introduction
  - Goal Statement and Objectives
- Design- Full and Bench Scale
  - Mechanical
    - Structural analysis
    - Safety
  - Electrical
    - Components
    - Flow Chart
- Testing
- Cost Analysis
  - Bench Scale Economic Analysis
  - Full Scale Economic Analysis
- Conclusion

Introduction

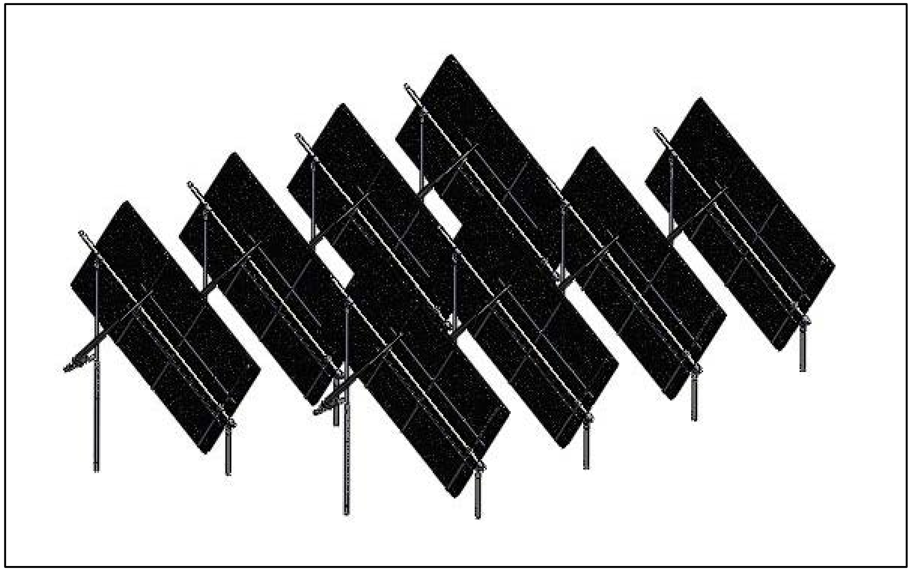
- Solar panels are most effective when pointed directly at the sun
- WERC: A Consortium for Environmental Education and Technology at NMSU in Las Cruces, New Mexico
- Sponsor: Dr. Thomas Acker

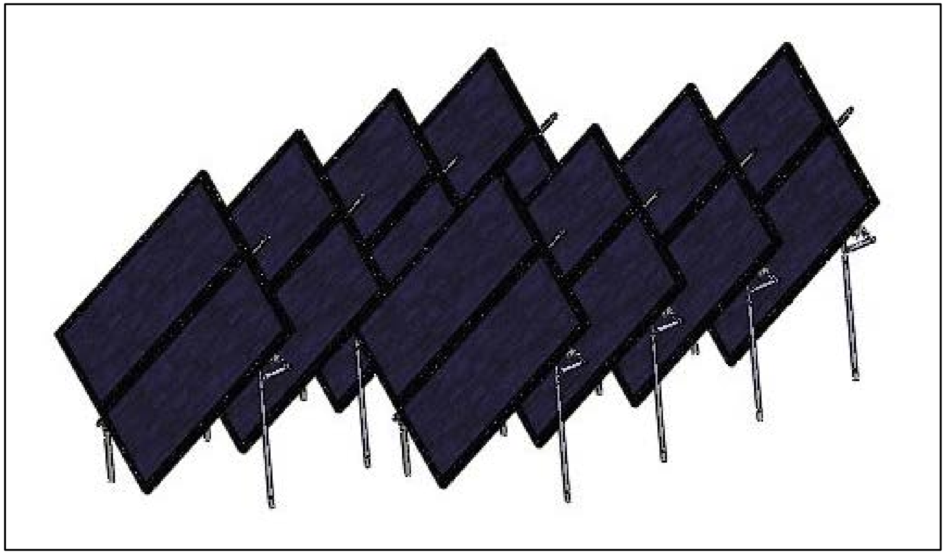
Goal Statement and Objectives

- Develop a maximum and efficient solar power tracking system
- Demonstrate its cost effectiveness
- Measure the difference in power generation with and without the solar tracking device
- Conduct a lifecycle cost analysis

Bench Scale Design

Full Scale Design





Structural Testing

- Frame can withstand at least 150lbs of force
- Actuator positioned for most effectiveness

Structural Analysis

Location	Yield (kpsi)	Max Stress (kpsi)	F.O.S.
3/8" Bolt in Elbow	24	0.905	26.52
Support Bar (Snow)	50	5.672	8.81
Support Bar (Wind)	50	11.34	4.41
Bottom Brackets	50	0.226	221.2

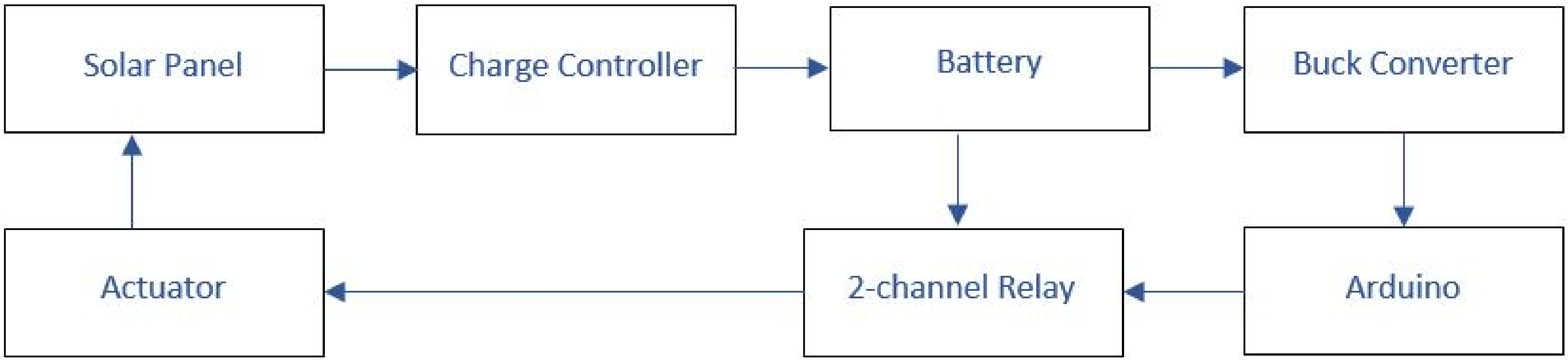
Safety

- Pinch Points
- Chemical Hazards
    - Battery
- Sharp Edges

Electrical Components

- Micro Controller
- Relay Module
- Buck Converter
- 12 Volt Linear Actuator
- Charge Controller
- Deep Cycle Battery

Electrical Flow Chart



Testing – Data Collection

Collected Data

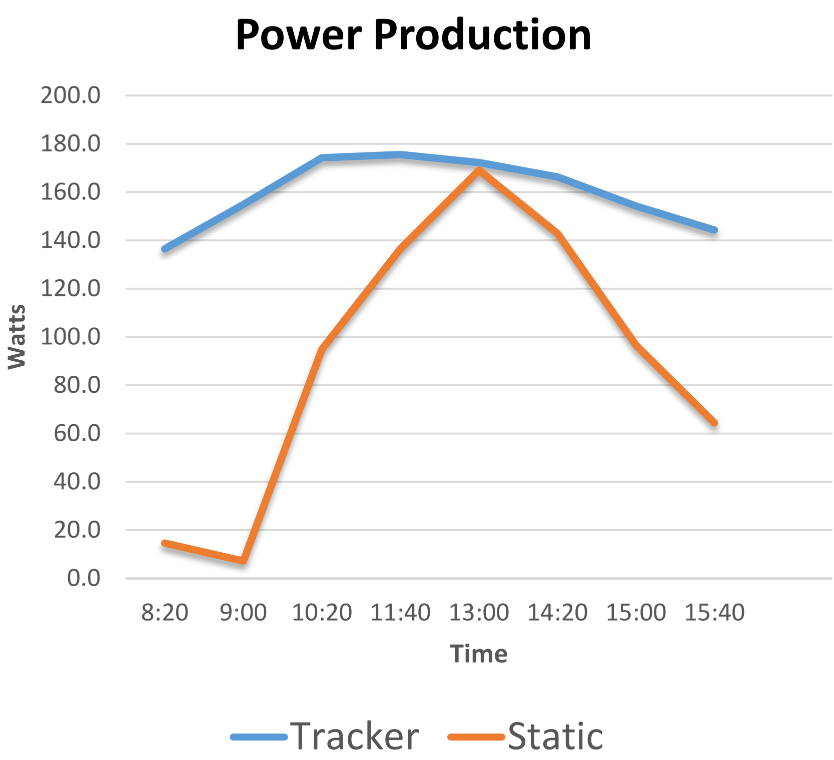


Table: Single day Power Generation

	Tracker				Static		
	Volts	Amps	Watts		Volts	Amps	Watts
Time							
8:20	21.0	6.5	136.5		20.0	0.7	14.6
9:00	22.0	7.0	154.9		21.0	0.3	7.1
10:20	22.0	7.9	174.2		21.0	4.5	94.9
11:40	21.0	8.4	175.6		21.0	3.5	73.5
13:00	21.0	8.2	172.2		21.0	8.1	169.1
14:20	21.0	7.9	166.3		21.0	6.8	142.8
15:00	22.0	7.0	154.2		21.0	4.6	96.6
15:40	21.0	6.9	144.3		21.0	3.1	64.5
17:00	21.0	4.9	102.9		21.0	0.6	11.6
Average	21.3	7.2	153.5		20.9	3.6	75.0
Difference	78.5 watts						

Cost Analysis

Part	Price ($)	Count	Total ($)	Source
1" Pillow Bearing	11.25	2	22.5	VXB.com
18" Linear Actuator	99	1	99	ECO-Worthy
1" Elbow	17.74	2	35.48	Hardtofinfitems.com
1" Tee	36.99	2	73.98	Hardtofinfitems.com
120" 3/4" Conduit	3.87	2	7.74	HomeCo
36"x1/8" Flat Steel	8.21	2	16.42	Home Depot
Square Steel Tube	16.21	2	32.42	Home Depot
1 1/4" PVC Tubing	2.35	3	7.05	Home Depot
Misc. Nuts and Bolts	10	1	10	Home Depot
60" U bar	16.09	1	16.09	Home Depot
36" Steel Angle	12.47	1	12.47	Home Depot
Arduino	60.00	1	60.00	Amazon
Buck Converter	5.00	1	5.00	Amazon
2 Channel Relay	5.00	1	5.00	Amazon
Junction Box	26.45	1	26.45	Amazon
Charge Controller	89.95	1	89.95	Flag. Sun and Wind
Battery	70.00	1	70.00	AutoZone
Misc. Parts	30.00	1	30.00	Radio Shack
Total			619.55	

Bench Scale Economic Analysis

- Assumptions
  - Flagstaff, Arizona
  - KC130M Solar Panel
  - 320 average days of sunlight at 10 hr per day
  - $0.11 per KWhr[2]
- Collected Data
  - Tracker average 150 W
  - Static average 75 W
    - Difference of **75 Watts**
- 11.7 Years to pay off
  - Note: Based off difference between structure and static

Full Scale Economic Analysis

- Based on a 20kW System in Phoenix, AZ
- Startup Cost
  - 255 Watts average per panel at $260 per panel (SW255)
    - 80 panels at $20,800 for 20 kW
  - 40 Structures
    - 10 Structures per microcontroller at $40 per controller
    - $9,400 for structures and installation
  - Total Startup = **$30,360**
- Maintenance
  - Assuming 6 actuators die per year
  - 20 hours per year changing North/ South axis
  - Total Maintenance = **$1,000 per year**

Full Scale Economic Analysis

- Power Generation
  - 3872 hours of sunlight per year (ncdc.noaa.gov)
  - Full structure generating an average of 20kW

    = 77440 kWhr
  - $0.1097 per kWhr

    = $8495.168 per year generated

- Profit = **$7,495 per year**
- Time to pay off: **4 years**

Competition

- Judge's Choice Award

Conclusion

- Final design chosen for simplicity and ease of manufacturing
  - Employed a low power micro controller and a low power low torque actuator
  - Available to average consumers for small and large scale applications
  - Lowest factor of safety for the structure was 4.4
- Tracking system almost doubled the average power output
- Total cost for bench design at $620
- Total cost for a 20kW system $30,360, not including land
  - Pay off at 4 years
- Won Judge’s Choice Award at the NMSU competition

Spring 2014

Thank You
Questions?

Citations

[1] NMSU, WERC "Environmental Design Contest-2014" Task 3-Power point Tracking for Solar Energy. (Web cite) http://www.ieenmsu.com/werc-2/design-contest-2014/tasks/task-3-power-point-tracking-solar-energy/

[5]U.S. Energy Information Administration. (2014, February 21). "Electric Power Monthly". [On-line].Available: http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a