ISES Solar Charging Station

Undergraduate Symposium

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Overview

- Introduction
- Problem Formulation
- Engineering Analysis
- Proposed Design
- Testing and Results
- Cost Analysis
- Conclusion

Introduction

- Sponsor is Dr. Thomas Acker
- Design a Solar charging station that can charge small electronic devices
- Two main subsections to the solar charging station
  - Structure
  - Control system

Problem Formulation

Need

- Northern Arizona University currently does not have a place that uses a sustainable, renewable energy source, that students and faculty could use in order to charge small electronic devices.

Goal

- Design a solar charging station capable of providing enough power to charge small electronic devices. As well, a structure to hold the system.

Yaqoub Molany

Problem Formulation

Operating environment:

- The system will be located outside the W.A. Franke College of Business, NAU
- Mostly sunny throughout the day
- Able to withstand:
  - Rain
  - Snow
  - Hail
  - High winds

Business Patio

Yaqoub Molany

Problem Formulation

Quality Function Deployment

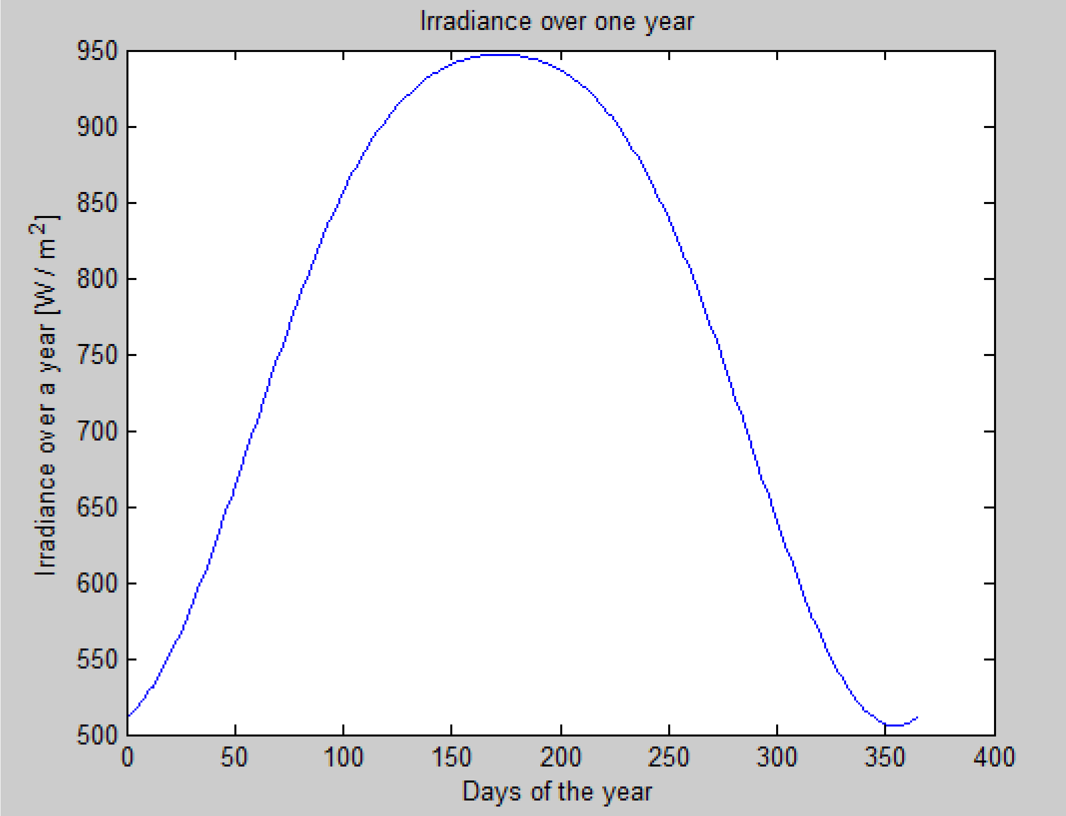
		Engineering Requirements				
		Energy	Stress	Cost	Yield Strength	Weight
Customer Requirements	Educational			x		
	Withstand Environment	x		x		x
	Charge Small Devices	x				
	Safe		x	x	x	x
	Inexpensive			x		
Units		kWhr	kPa	$	kPa	N

Yaqoub Molany

Engineering Analysis

- Solar Irradiance in Flagstaff
- Energy produced a day
- Structure

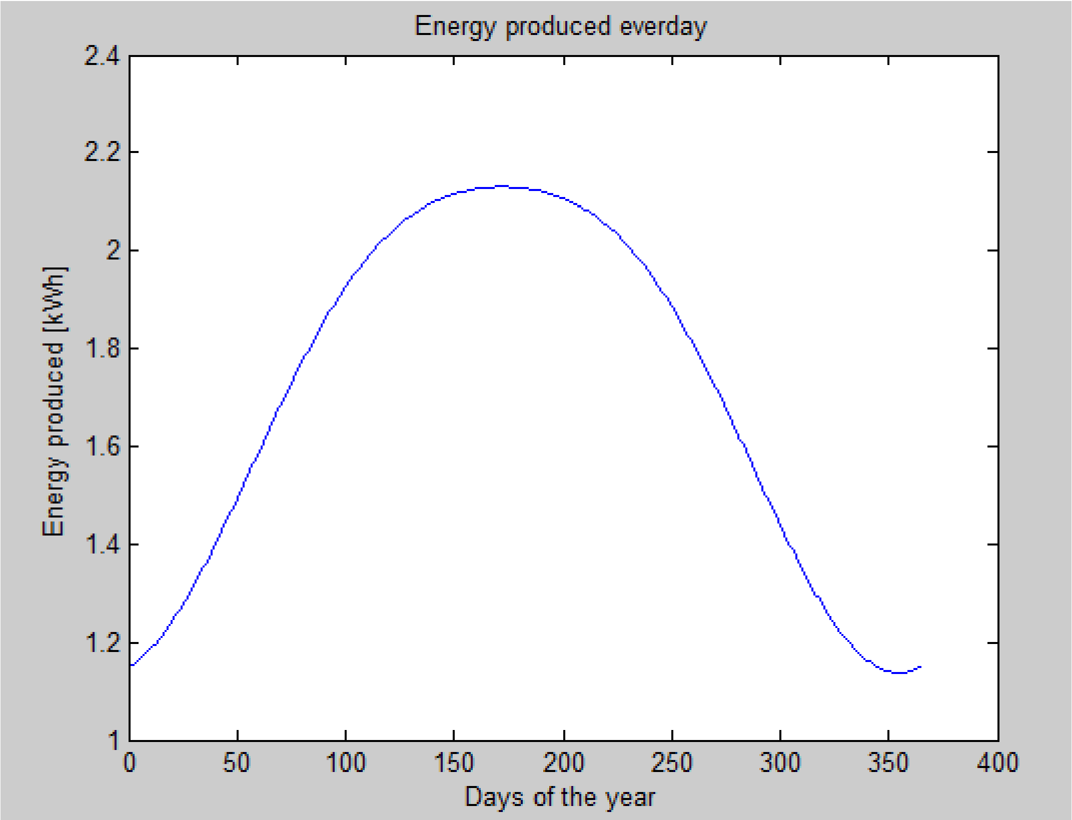
Irradiance



Average Irradiance:

- in summer ≈ 950 W/m^2
- in winter ≈ 520 W/m^2

Energy

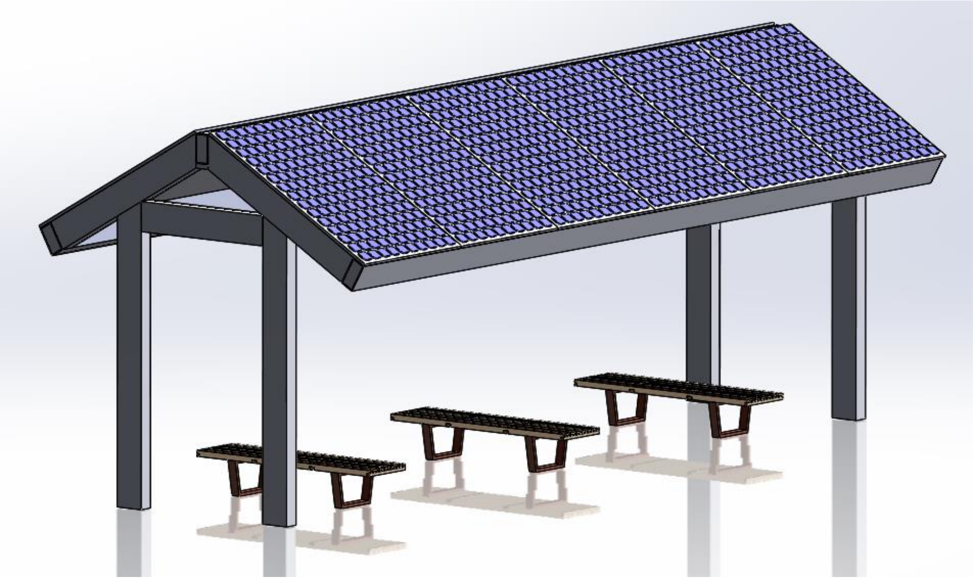


For each panel:

- 2.1 kWh in summer a day
- 1.1 kWh in winter a day

Structure

Structure for housing components

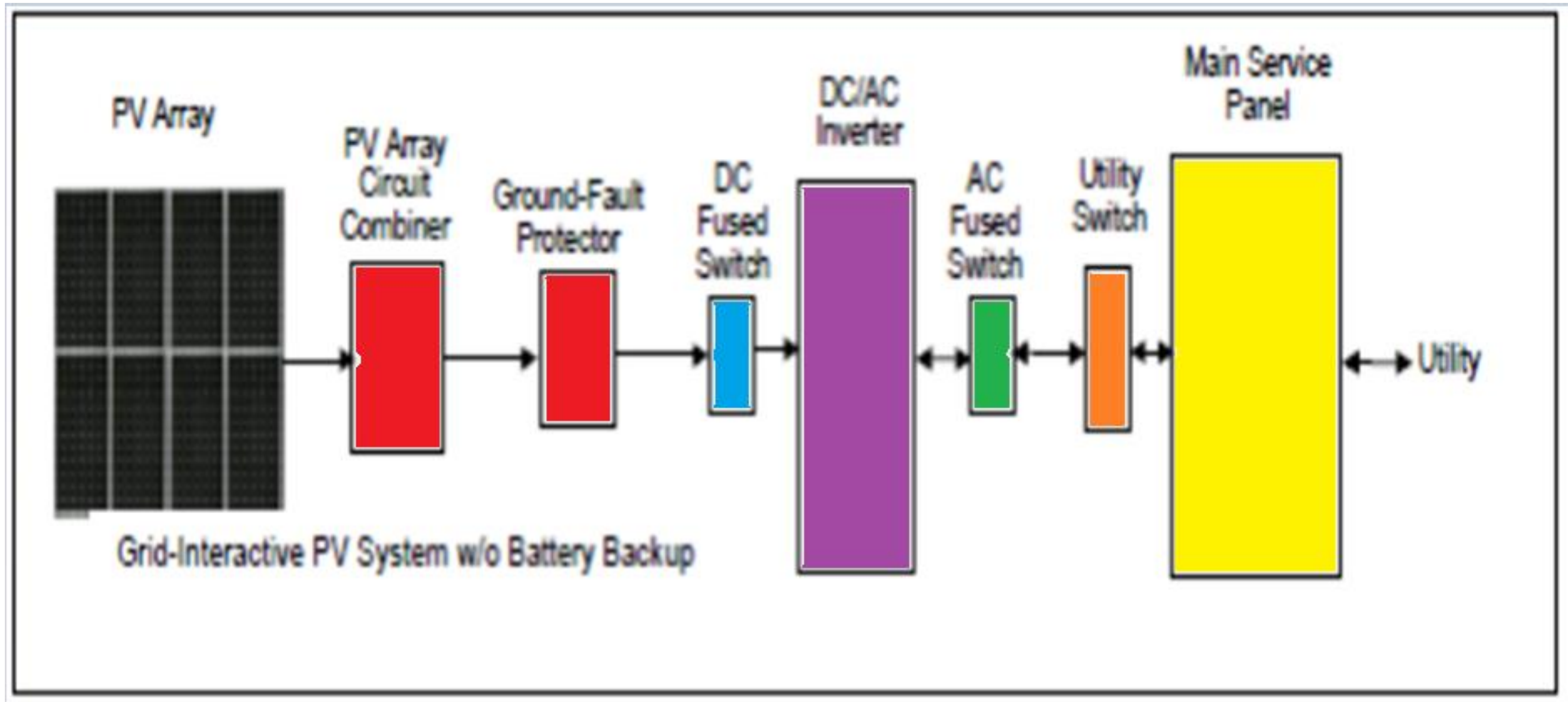


- Rectangular Steel Tubing
- ASTM A500, grade B
- Sizing: 10” x 5” x $\frac{3}{8}$ ”
- Easy to weld the entire structure together
- Roof angled at 35°

Ze Chen

Proposed Design

Grid tied system



Credited to Endecon Engineering

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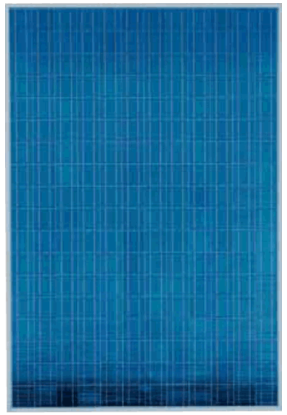
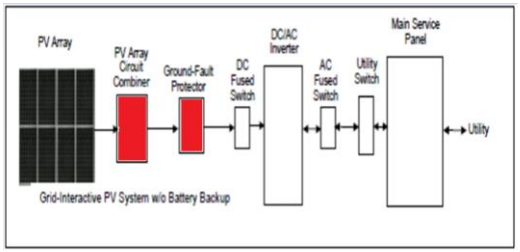
Design Components

- Six ASE-300-DGF/50 Solar panels
  - Peak panel efficiency: 12.4%
  - Max Power output: 300W
  - Max Voltage output: 50V



- MidNite Solar PV Combiner Box
  - Holds 600VDC fuse for overcurrent protection
  - Contains bus bar for negative grounding of PV array

Credited to SMA



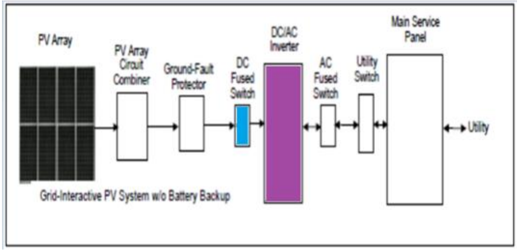
Tyler Faulkner

Final Concept Components

- Square D, DC Disconnect Switch 600V, 30 amp
    - Safety shutoff positioned before the inverter

- SMA Sunny Boy 2000W High Frequency Grid-Tie Inverter
    - Converts DC power into AC power at 60Hz
    - CEC Efficiency: 97%
    - Input voltage range from 175V to 600V
    - Built-in DC disconnect

Credited to SMA



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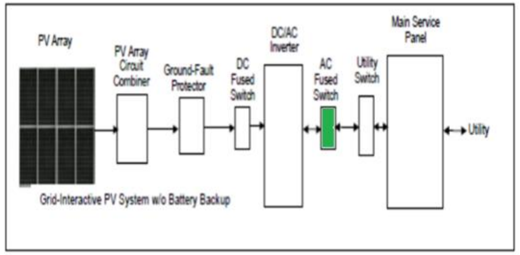
Final Concept Components

- Square D, AC Disconnect Switch 600V, 30amp
  - Safety shutoff positioned after the inverter
- Sunny Beam Monitoring System
  - Communicates with inverter via Bluetooth
  - Displays key data including:
    - Current production profile
    - Total energy yield for the day/month/year
    - CO_2 emission savings



Credited to SMA

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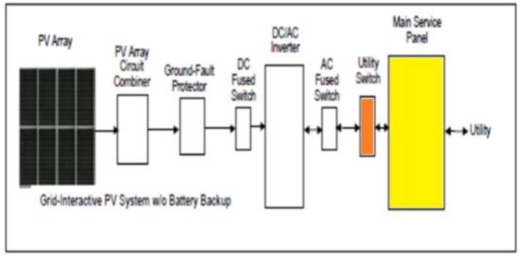
Final Concept Components

Credited to SMA

- Bidirectional Focus Digital Utility Meter
  - Measures energy input to the grid in kWh
  - Measures energy drawn from the grid to charge
  - Required by the National Electrical Code
- Square D Meter Socket Ring Type 600VAC, 125 amp
  - Houses Utility Meter
- Dual Conducting 600V Direct Burial #12 AWG Copper Wire



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Design Schematic

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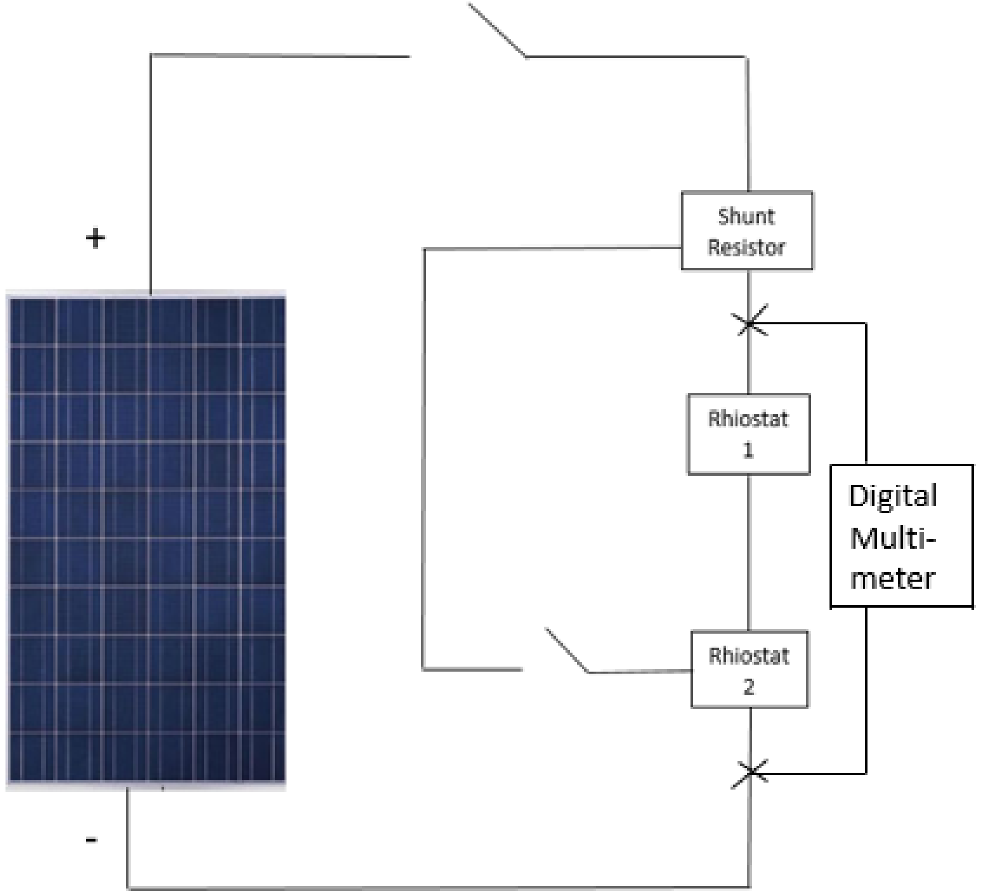
Testing and Results

- Panel testing
- Panel testing results
- Expected amount of devices charged in a day

Thomas Penner

Testing and Results

Panel Testing Schematic



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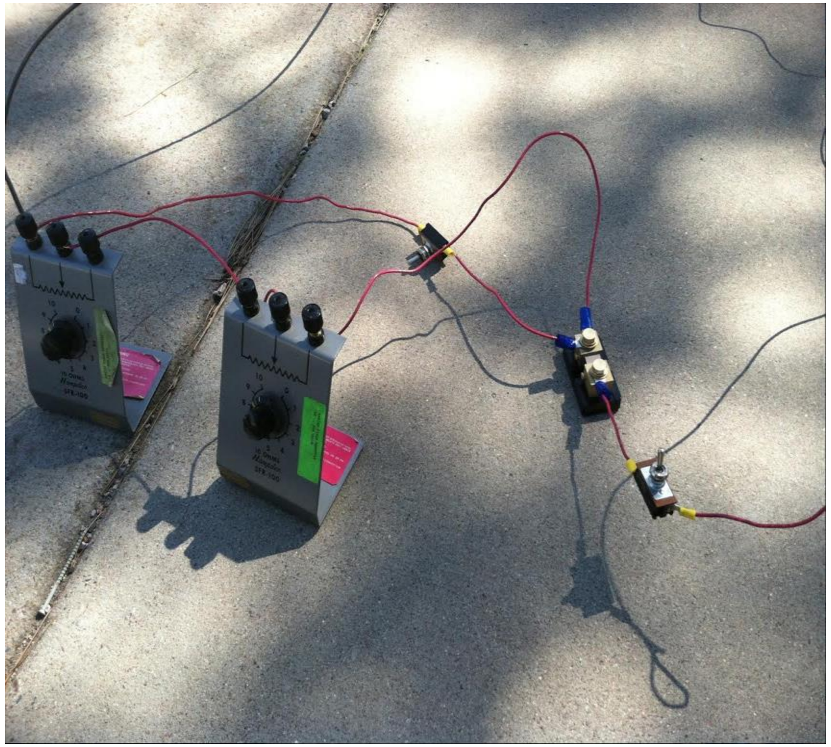
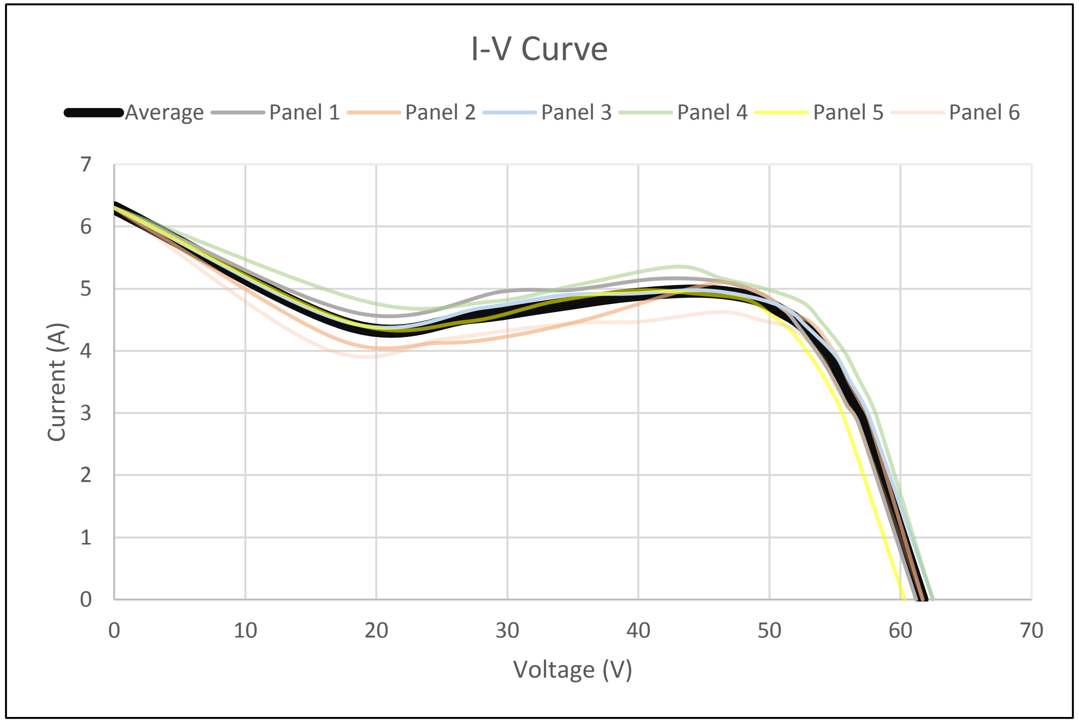
Testing and Results

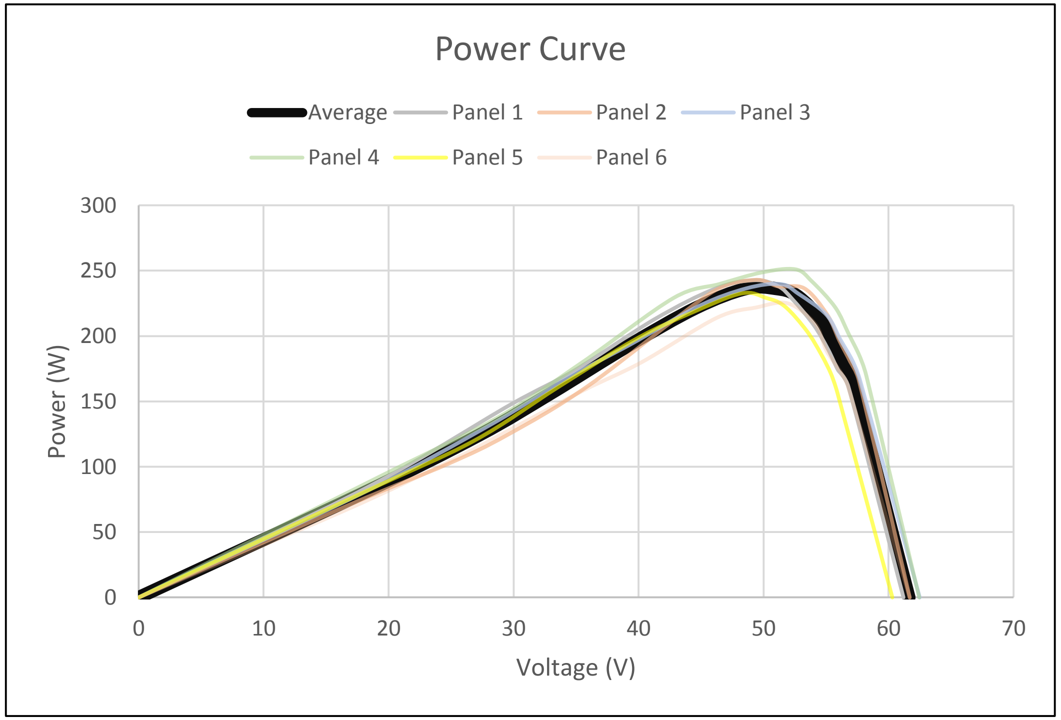
Demonstration of the actual testing system



Testing and Results

- Average data curves from all tested panels
- Panel efficiency: 9.45% (calculated)





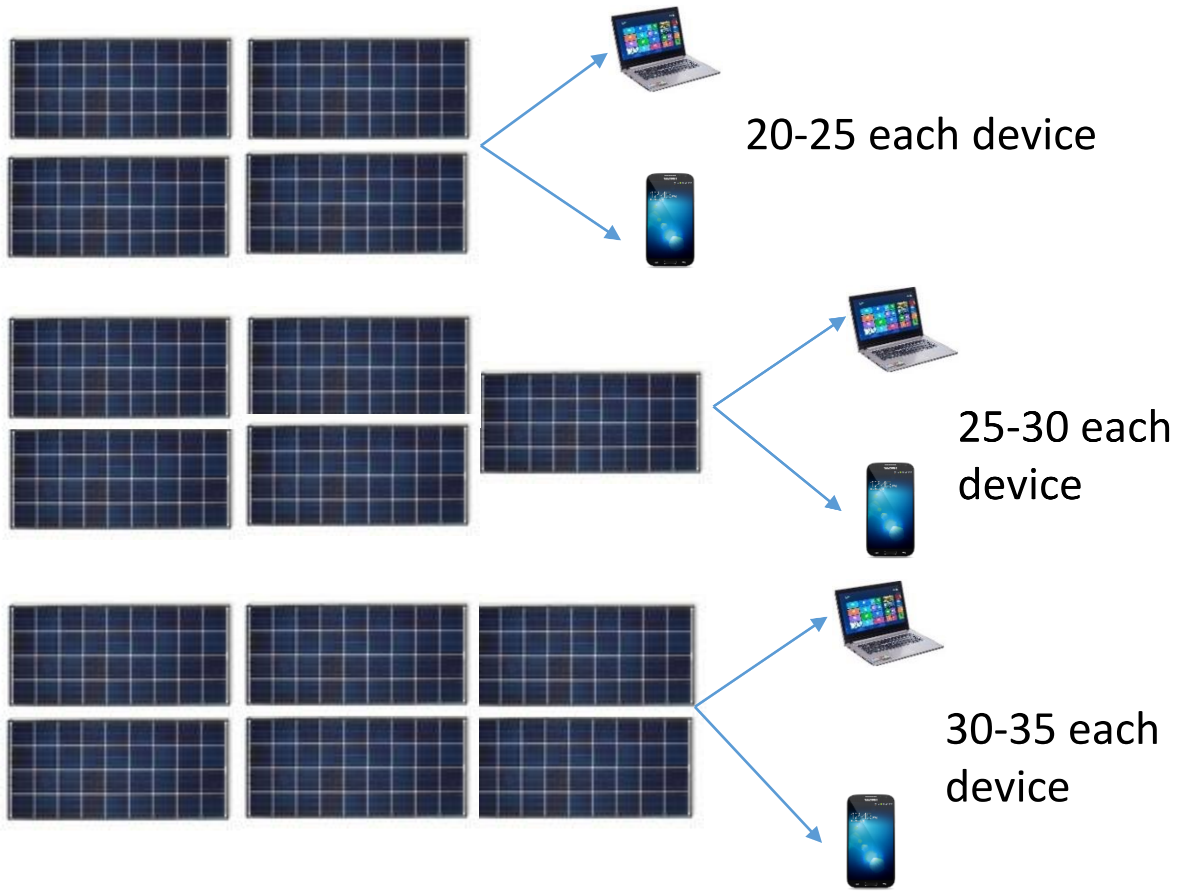
Testing and Results

- Panel Power Output: 236W
- Inverter efficiency: 97%
- Table of Energy Output:

	Energy Output		
Number of Panels	Summer	Winter	Average
1 Panel	1.37 kWh	0.92 kWh	1.15 kWh
4 Panels	5.49 kWh	3.66 kWh	4.58 kWh
5 Panels	6.87 kWh	4.58 kWh	5.73 kWh
6 Panels	8.24 kWh	5.49 kWh	6.87 kWh

Testing and Results

- Assuming each cellphone requires 10 W-h
- Assuming each laptop requires 100 W-h



Thomas Penner

Bill of Materials

Item	Unit Price	Quantity	Total Cost	Application
Sunny-Boy inverter	1597.00	1	1597.00	High frequency inverter, 240 VAC, 2000 Watts, 10 year warranty
Sunny-Beam Display	236.93	1	236.93	Wireless System monitor with Bluetooth. Will display consumption information for educational purposes.
DC Disconnect	170.00	1	170.00	This pulls the solar panels off line in case of emergency
Digital utility meter	156.00	1	156.00	Bidirectional meter for utility reasons
Square D meter socket	121.04	1	121.04	The main plug for the system, box for meter
Combiner box	73.75	1	73.75	MidNite solar PV combiner box, protects the system from overcurrent
AC disconnect	58.67	1	58.67	Square D disconnect switch. 240v ac, NEMA 3R, 2pole, 30 amp
Fuse holder	4.65	1	4.65	Required by Arizona code, protects the system from having a power surge
Charging sockets	3.25	6	19.50	Where students can charge their electronic devices.
Fuse (600V DC)	3.05	1	3.05	Required by Arizona code, protects the system from having a power surge
12AWG double conducting wire	0.90	80	72	Connecting electrical components of the system
Total			2512.60	

Alexa Kearns

Cost Analysis

- Manufacturing costs
  - Control system materials
  - Construction costs
- Man power
  - 50 hours per worker
  - $15 an hour
  - 10 workers
- Minimum predicted total cost: $10,000

Alexa Kearns

Conclusion

- Creating a grid connected solar charging station for small electronic devices
- 11 component system included the Sonny-boy inverter
- Up to 8.24 kWh and average of 6.87 kWh produced by 6 panels in a day
- Can charge an average of 30-35 cell phones and laptops per day
- Minimum total cost: $10,000

Acknowledgments

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  - John Sharber (EE)
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Questions?