Parabolic Trough

Tracking and Energy Extraction

UGRADS Presentation

Team14

Saad Almonnieay, Robert Blaskey, Daniel Chief, Christopher Mesko, Jairo Rivera, and Jacob Seitzer

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NORTHERN ARIZONA UNIVERSITY

Overview

- Introduction
- Project Definition
- Initial Conditions
- Repairs and Replacements
- Tracking System Controls
- Energy Extraction System
- Results
- Cost of Project
- Conclusion

Introduction

Northern Arizona University was gifted a parabolic trough 15 years ago, however the trough has not been operated or maintained since it was donated. Damage over time affected all of the components of the trough, some more severely damaged than others. The trough was lacking a system to extract the solar energy it provides.

Overall Picture of the System

Project Definition

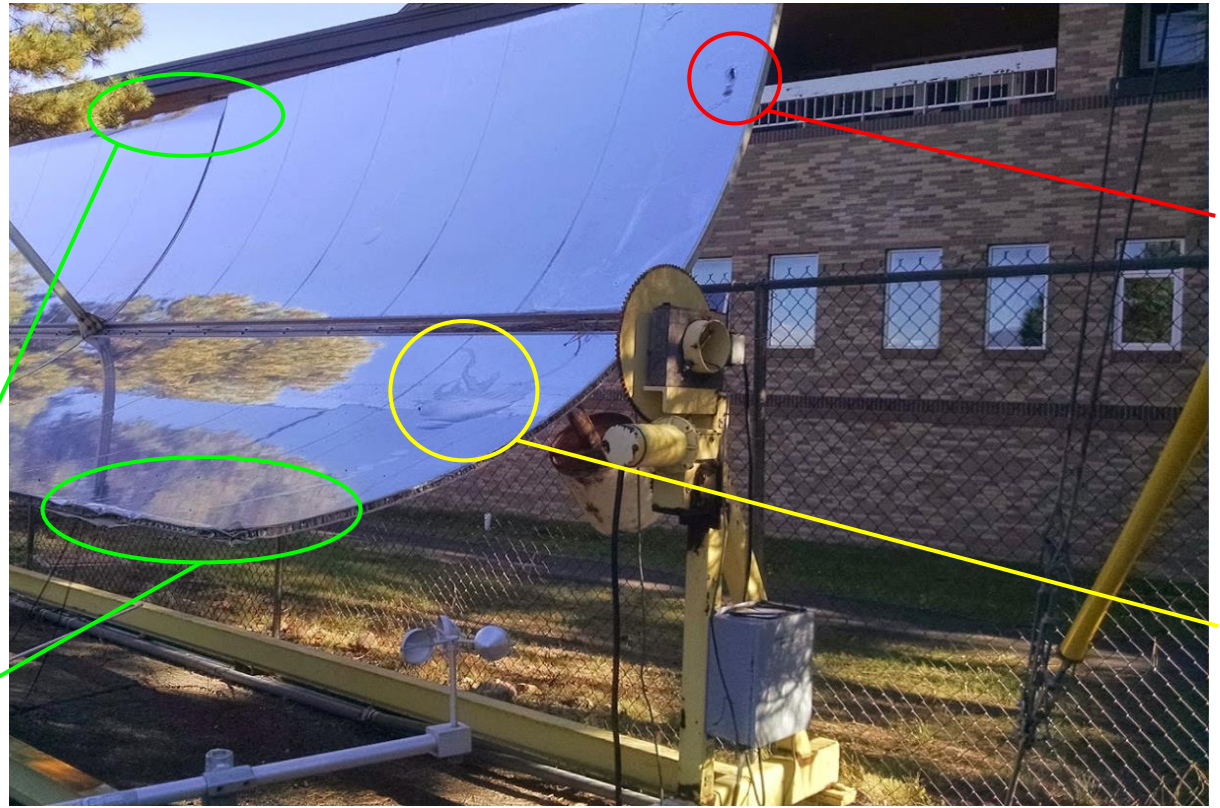
Customer Needs

- Operable tracking system to move the parabolic trough
- Extraction system to make use of the solar energy

Project Goals

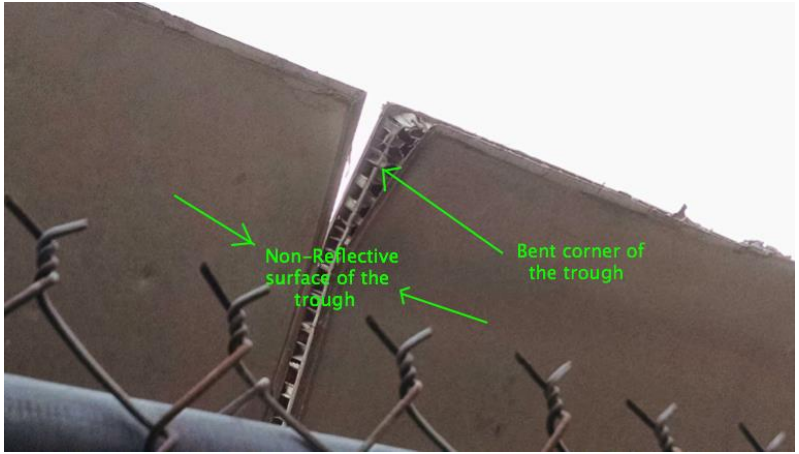
- Repair the parabolic trough tracking system
  - Replace tracking system components and damages
  - Programmable control system
- Design an energy extraction system
  - Create a recirculating piping system
  - Store heated liquid in a tank

Initial Conditions



Parabolic Surface Initial Condition

Initial Conditions



Parabolic Edges

Motor and Control Box Location

Tracking System Repairs and Replacements

Repairs:

- Mylar sheets to cover holes and water damage in parabolic surface
- Gear box cleaned and returned to operable conditions
- Aluminum trimming to cover frayed edges

Replacements:

- All four tires, including one caster/wheel assembly
- Chain connecting gear box to the trough in order to properly rotate
- Control box and all electrical components
- 1HP, 3-Phase AC motor to replace the previous DC motor of unknown specifications

Tire Information

- 4 Marathon wheels and tires assembled
- 4 ply
- 300 lbs capacity per tire and wheel
- 10.5 inches height
- 3/4 in bearings

Damaged Tire

Replaced Tire

Chain Information

- Steel ANSI 50
- 7 Feet
- ⅝ inch pitch
- ⅜ inch roller width
- 561 lbs working load

Installed Chain

Gear Box Maintenance

- The gearbox was taken to Coconino Auto suppliers in Flagstaff, AZ, and cleaned professionally from the rust and oil.
- Replaced gaskets and hardware
- 75W-90 Gear oil

Gear Box Maintenance

Before

Upper Gear Box

After

Upper Gear Box

Lower Gear Box

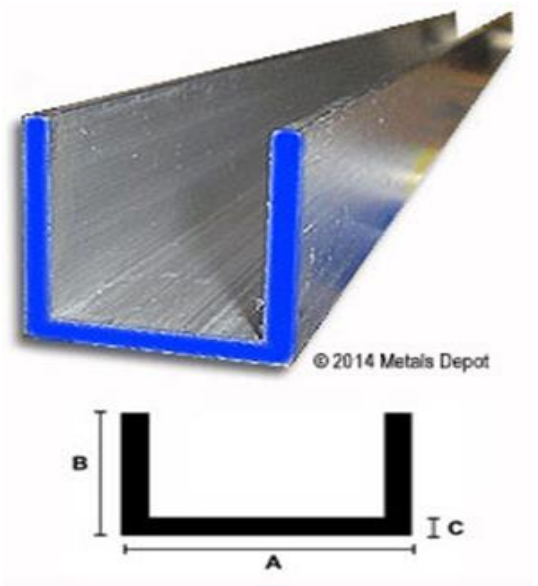
Gear Box Shaft

Lower Gear Box

Gear Box Shaft

Edge Trimming

- 6063-T52 Aluminum Channel (Sharp Corners)
  - Cheaper than plastic
- Dimensions
  - Width(A) = 1.25’’
  - Legs(B) = 1.25’’
  - Web Thickness(C) = .125’’
  - Leaves 1’’ as the inner width.
- 2” sections cut for curved edges
- Adhesive: Loctite PL375 Heavy Duty



(**Source:** Metals Depot)

Installed Trim

Overall

Inner Corner

Inner

Outer Corner

Control System

Old Motor
- Specifications unknown

New Motor
- 1 HP
- 230V
- AC 3-Phase
- 56 C-Face

Previous Motor

New Motor

Control System

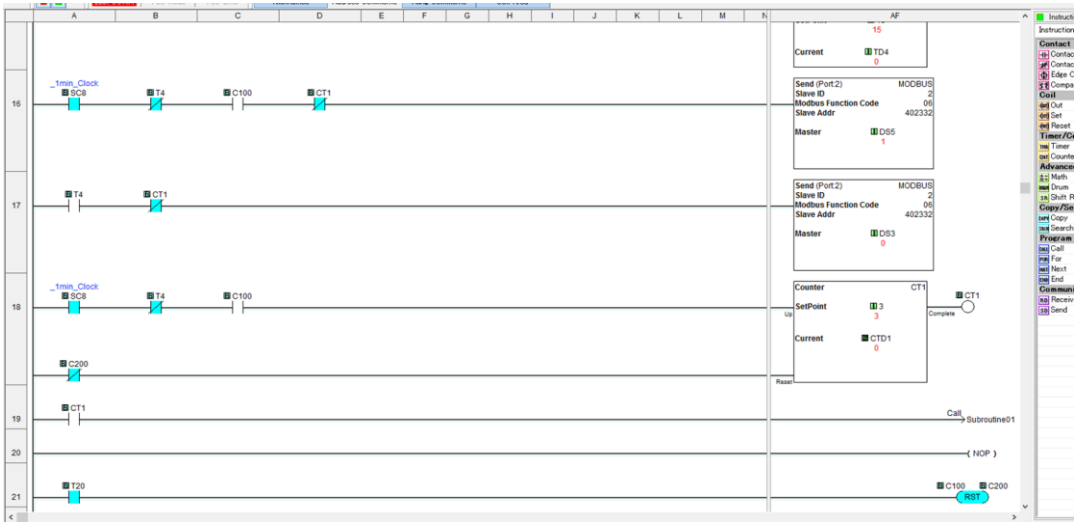
- All components replaced
- Up-to-date, simplified
- Unlimited possibilities for future uses

Initial Condition of Control Box

New Control Box

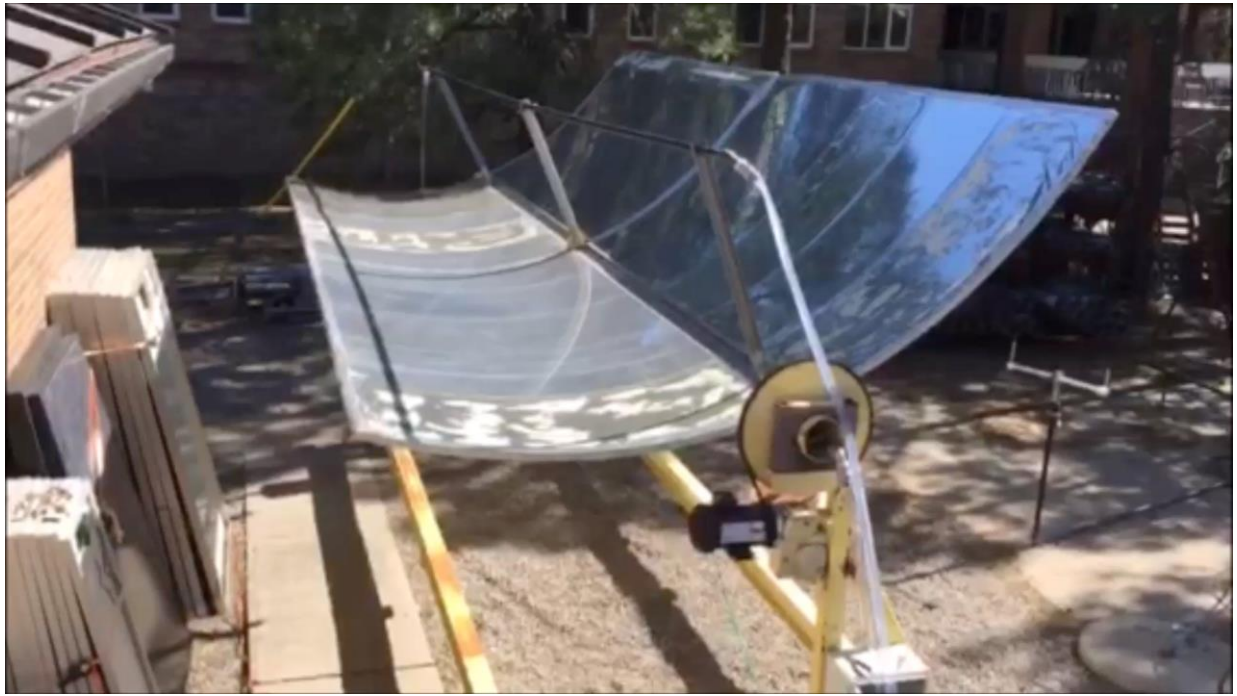
PLC Programming

- CLICK Programming Software
- Relay Ladder Logic
- What it does



PLC Program

Motion of Trough



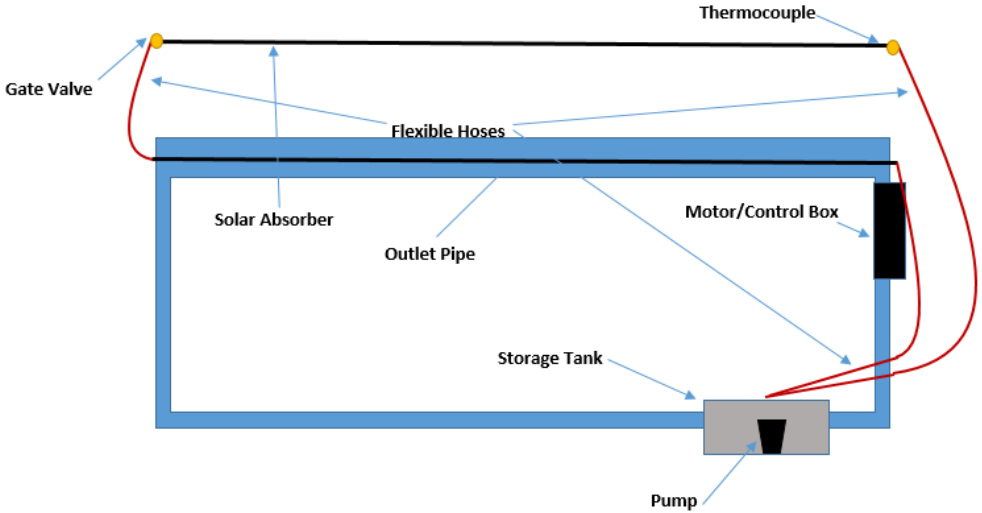
Video of the Trough

Previous Extraction System

Initial Condition of Extraction System

Energy Extraction Parts

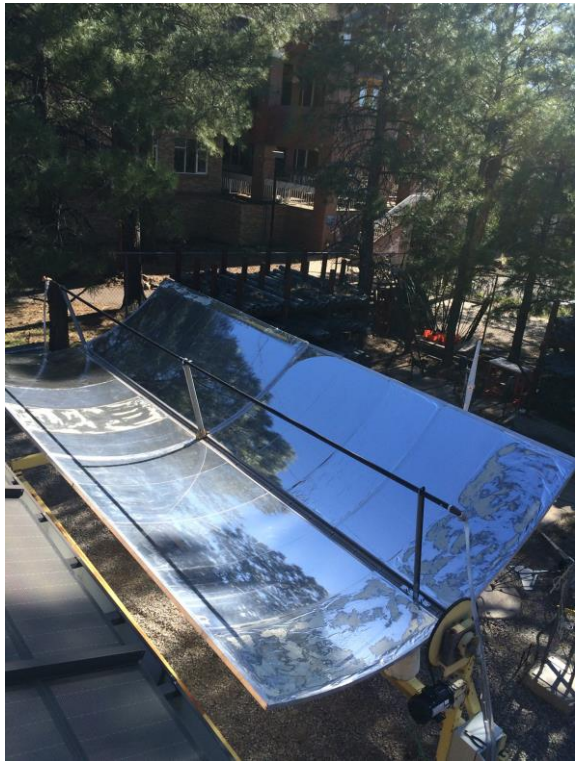
- 40 feet of steel pipe
- 30 feet of flexible hosing
- Little Giant Water Pump
  - 1” outlet
  - ⅙ HP
  - Maximum flow 750 GPH
- Adjustable gate valve
- Mounted K-type thermocouple
- 55 gallon water tank



Schematic of Extraction System

Energy Extraction

Inlet and Outlet



Solar Absorber

Flow nozzle

Water Pump

Pump Specifications:

- Submergible pump from Homco in Flagstaff
- Runs at maximum 750 GPH
- 1/6 HP power
- 1’’ diameter output

Water Pump

Water Storage

Water storage Specifications:

- A rectangular tank from the Plastic Water Tanks Company.
- 55 Gallon tank
- 8’’ fitting in the top
- Dimensions of 42’’x26’’x16’’ (Width x Length x Height)

(**Source**: PlasticWaterTanks.com)

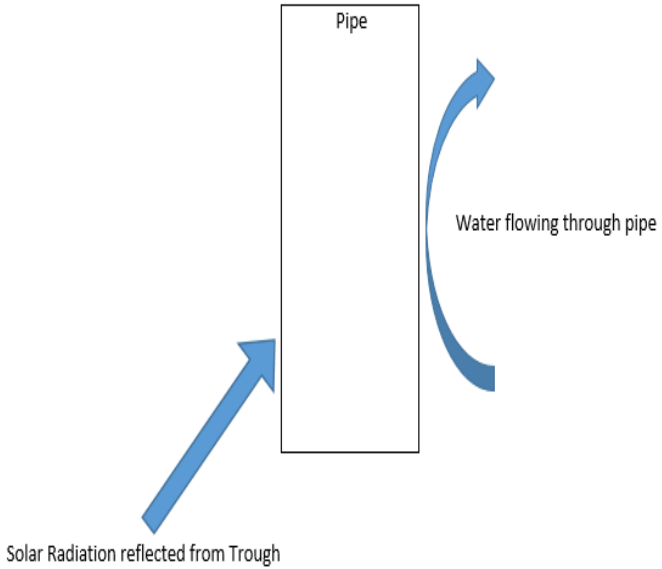
Final Solar Energy System

Side View of Energy System

Front View of Energy System

Solar Energy Results

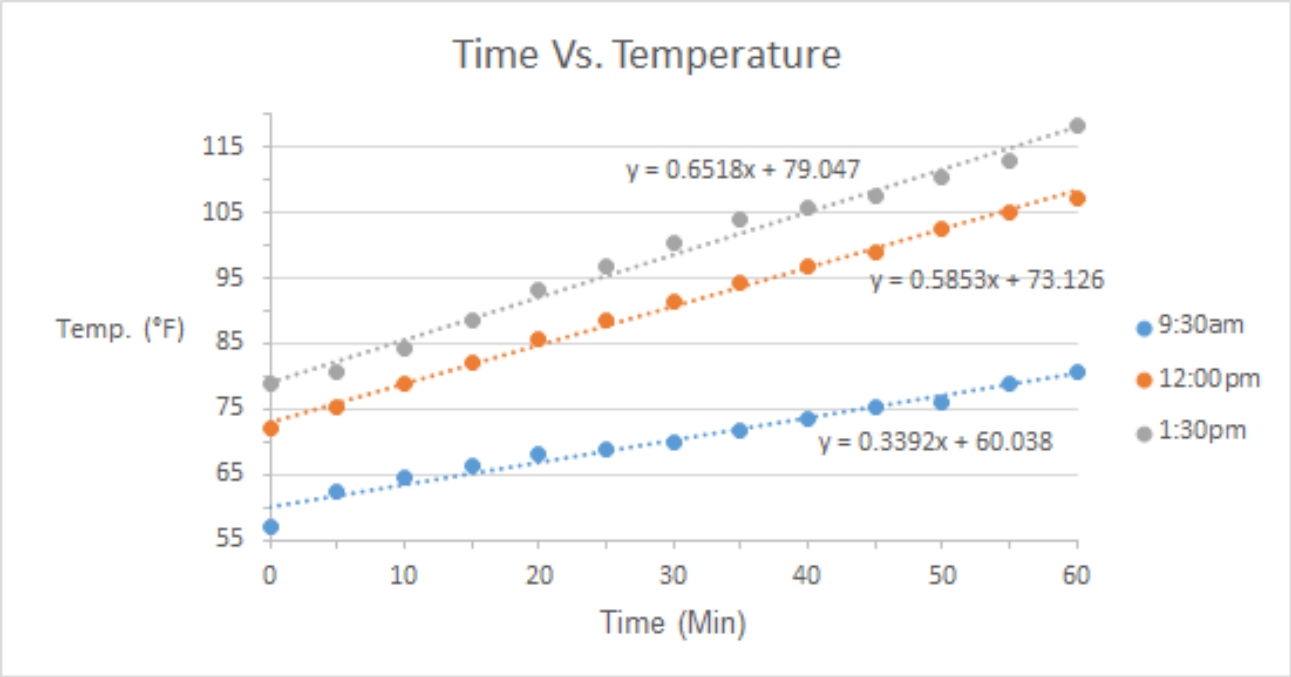
- Pipe temperature: 350º F in 10 minutes
- Two different tests for 15 Gallons of recirculating water
  - Constant Flow rate at different times of the day
    - 750 Gallons Per hour
    - Clear Sunny Skies with low of 27º F and high of F
  - Constant change of temperature at different flow rates
    - 40º F temperature change
    - Roughly same time of day



Schematic of heat transferred to the pipe

Solar Energy Results

- Constant 750 GPH flow rate at different times of the day



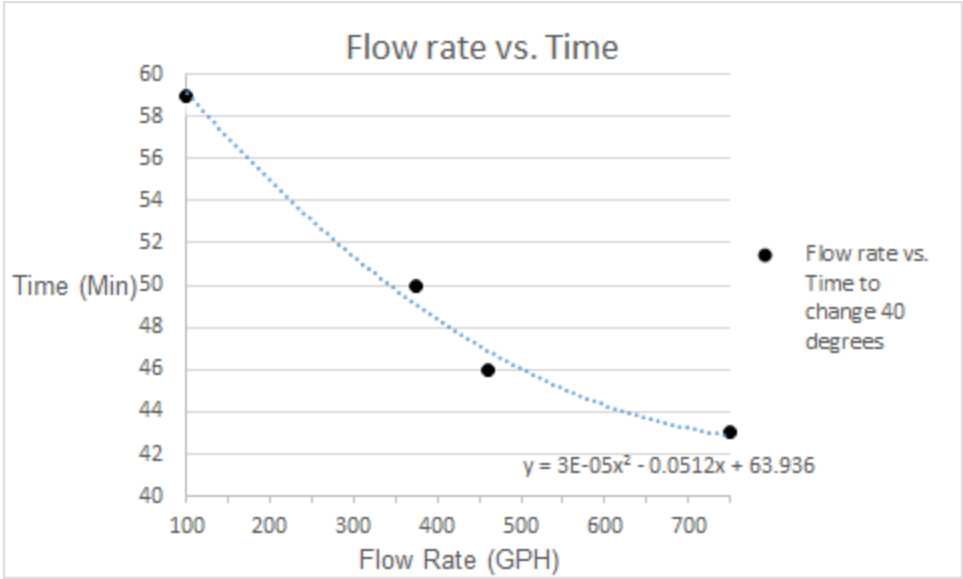
Temperature vs. Time graph

Solar Energy Results

- Constant change of temperature at different flow rates

Flow, Temperature range and Time Table

Flow (GPH)	Temp. Range (°F)	Time (min)
750	73-113	43
460	72-112	46
375	68-108	50
100	70-110	59



Flow, Temperature range and Time Graph

Total Cost

Repairs and Replacements of Tracking System Cost

Repairs and Tracking System	
Tires	$58.00
Caster	$71.48
Chain	$41.86
Motor	$279.00
Drive	$186.00
PLC	$151.00
Control Box	$102.00
Trim	$220.38
Adhesive	$7.20
Gearbox	$51.50
Mylar	$20.02
Motor Cover	$23.75
Total	$1,212.19

Solar Extraction System Cost

Solar Extraction	
Piping	$162.50
Storage Tank	$168.00
Storage Frame	$104.33
Pump	$110.00
Misc.	$170.10
Total	$714.93

Total: $1,927.12

Conclusion

The tracking system is now operable. The motor, chain, and tires have been replaced, and the gearbox has been restored. Aluminum trimming has been added to secure the edges of the trough, as well as Mylar added to cover the damaged panels. The energy extraction system has been installed to make use of the of energy provided by the sun. With an operable tracking system and energy extraction system, the parabolic trough is ready to demonstrate how solar energy can be reflected onto a fixed pipe to heat a liquid. If continuing on with this project, programming the tracking system to complete specific tasks would be the main focus.

Acknowledgements

- Motion Industries
- Perry Wood
- Coconino Auto
- NAU Machine Shop

References

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Questions?