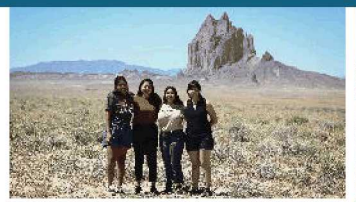
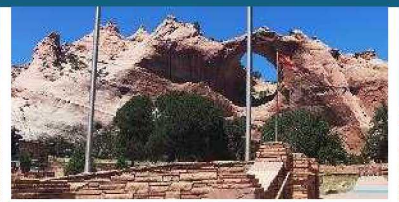
SAND2019-9604PE

Sizing Small Scale Renewable Energy Systems for Navajo Nation and Rural Areas

PRESENTED BY

Callie Singer, DOE Indian Energy Intern

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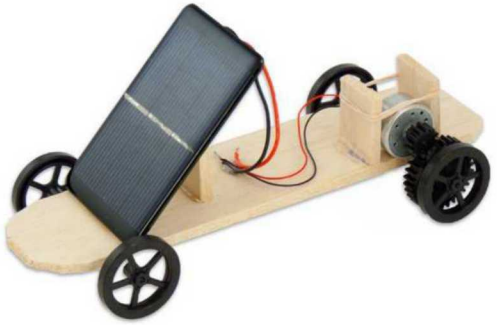
Outline

- Personal Background
- Motivation
- Research Approach
- Results & Discussion
- Next Steps
- IE Program Overview

Personal Background

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science



ASCE
COLUMBIA UNIVERSITY

Columbia University
Native American Council

Motivation

- The Extraction Industry on Navajo Nation
  - Disruption of the natural landscape
  - Negative health effects
  - Economic dependence on extractive industries

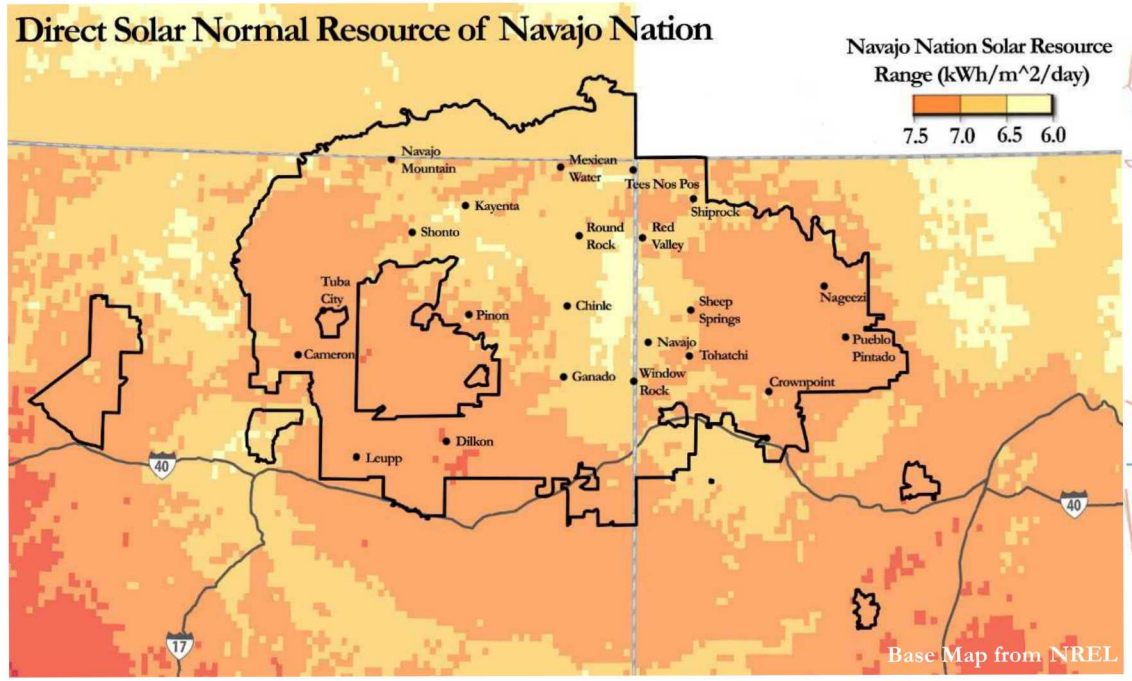
- Generating stations and mines closing down
- Navajo Sunrise Proclamation for an energy transition from carbon-based into renewables
  - Rural electrification
- Costs for connecting to the grid the farther the household is away from distribution lines

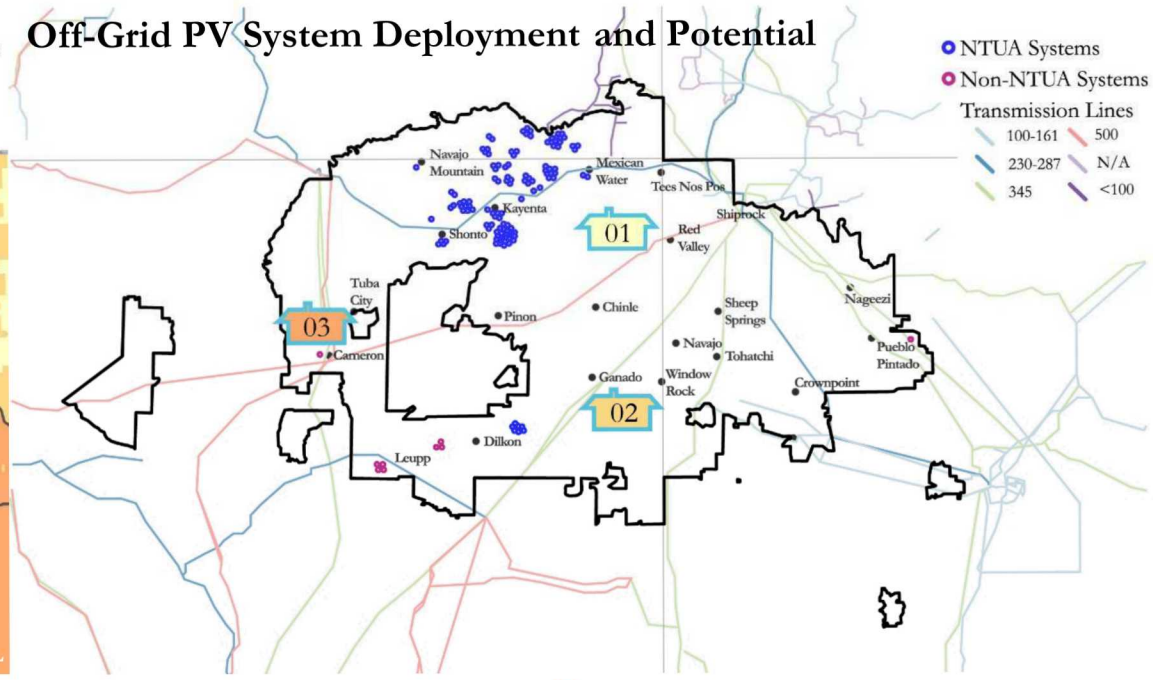
Research Approach

- Researching current methods of off-grid PV system deployment at different scales
  - NTUA (Site Visits)
  - Native Renewables, Navajo Power, GRID Alternatives, Gallup Solar, Eagle Energy
- Planning for housing and renewables from NN and other tribes
- Understanding the relationship to the individual household
  - Different locations and family size
    - Solar resource and load requirements
- Sizing PV Systems: Sandia PV design
  - Solar resource mapping
  - MATLAB calculations
  - Contacting PV suppliers
  - Component specifications

NTUA Hybrid System, Photo from DOE

Results & Discussion





01 Potential Home 01

- Lukachukai/Tsaile Chapters
- 6.0-6.5 kWh/m^2/Day
- 3 kW (NTUA considering)

02 Potential Home 02

- Kinlichee Chapter
- 6.5-7.0 kWh/m^2/Day
- Elder Load

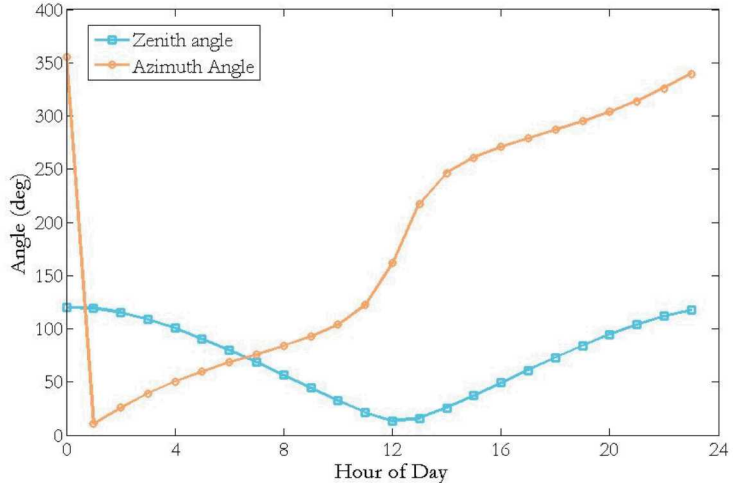
03 Potential Home 03

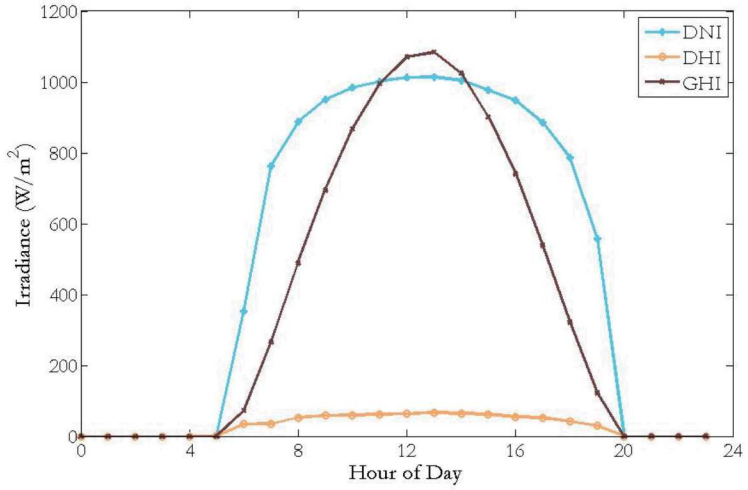
- Cameron/Coalmine Mesa Chapters
- 7.0-7.5 kWh/m^2/Day
- Small Family Load

Environmental Parameters

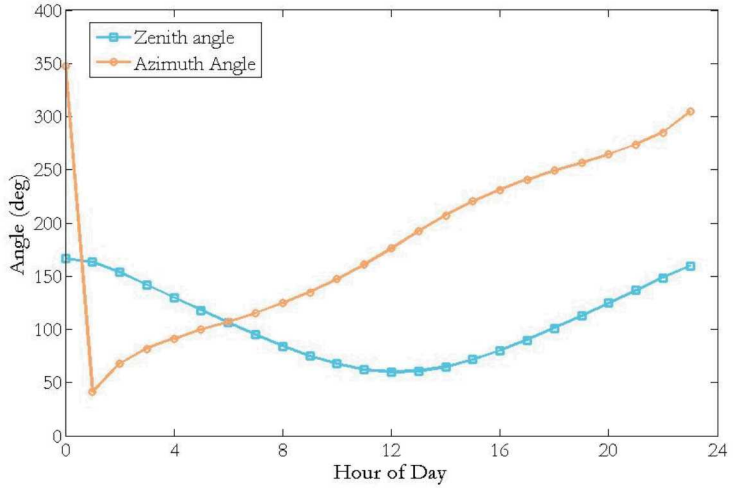
01

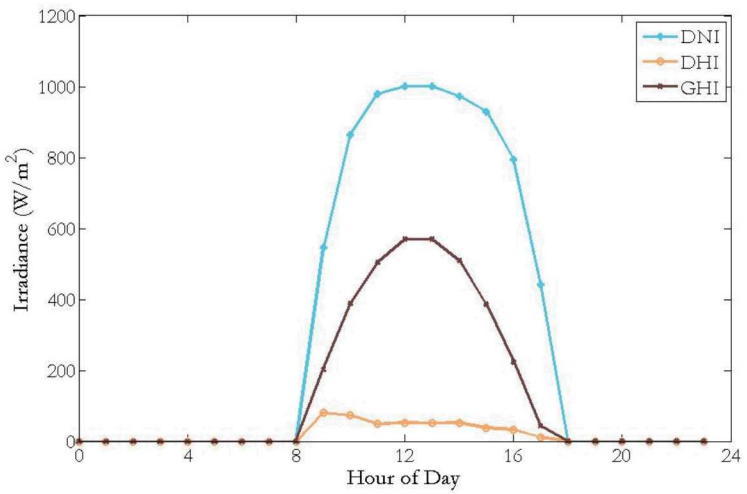
Summer Solstice (Jun 20)

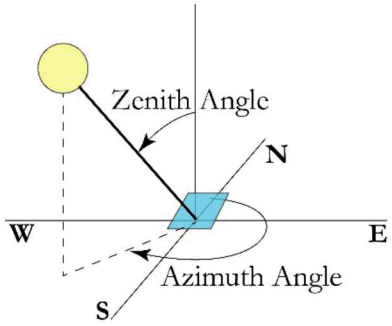


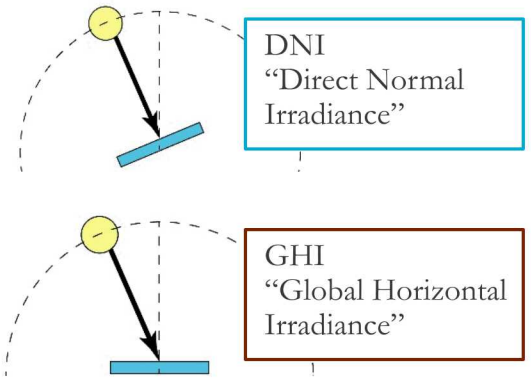


Winter Solstice (Dec 21)









Loading Requirements

01 02 03

- Small Scale / Residential size typically 2-10kW
  - NTUA ranges from .68 – 1.8 kW
  - Mainly for lights and refrigerator
- Determined by Household Size
  - Number of family members
  - Household demographic: single family, elder, etc.
  - Use of appliances
  - Time of day of energy consumption
- Approaches
  - Appliance Wattage * Hours of Use / 1000 = kWh / Day
  - Load quantity * Current * Voltage = AC Load Power (W)

PV System in Leupp,
Photo from GRID Alternatives

PV System Design

- Sizing Process
  - Calculate the Loading Requirements
  - Calculate System Battery Size
  - Calculate Array Size
  - Determine necessary components
    - Modules
    - Combiner Box
    - Charge Controller
    - Inverter
    - Battery
    - Backup Generator

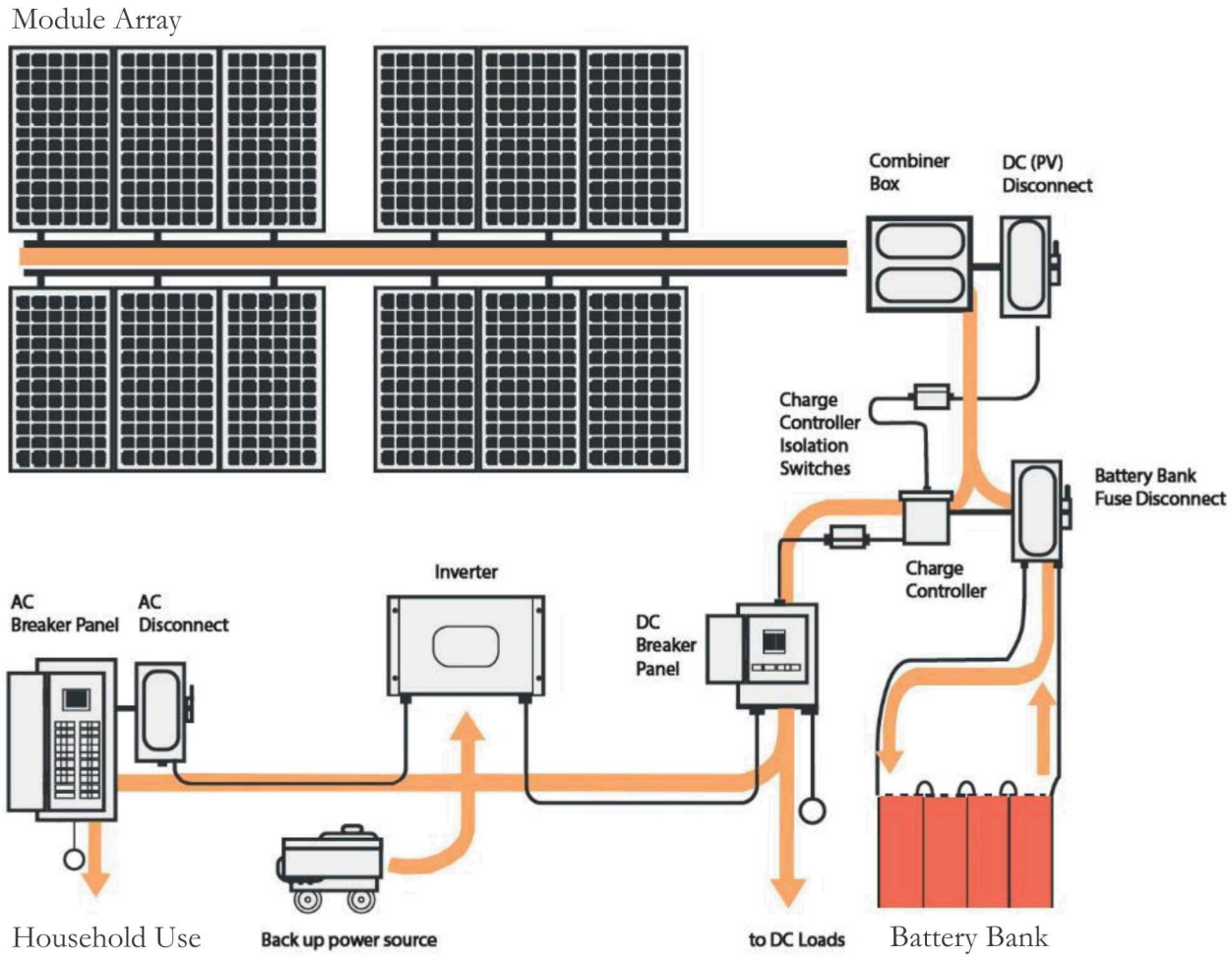
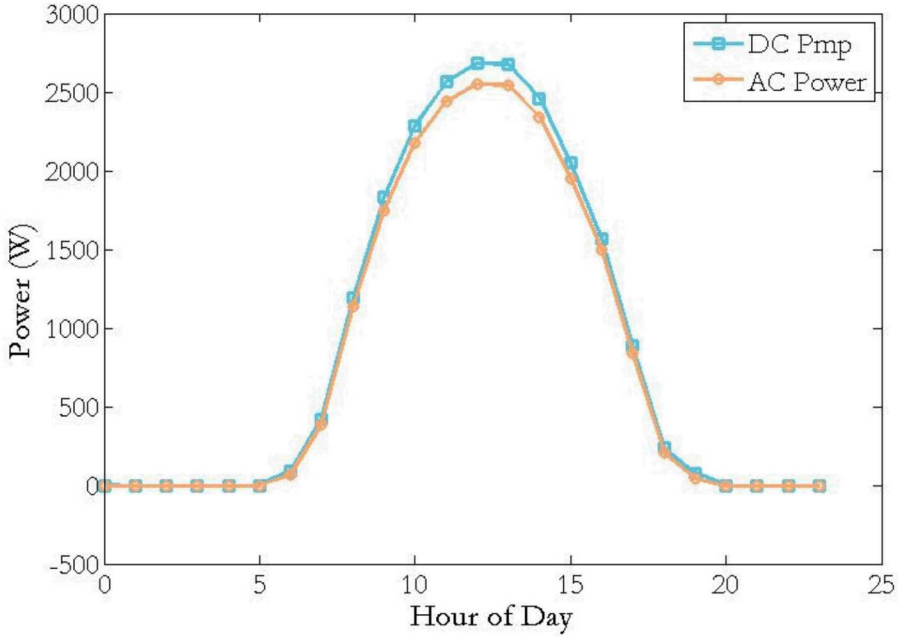


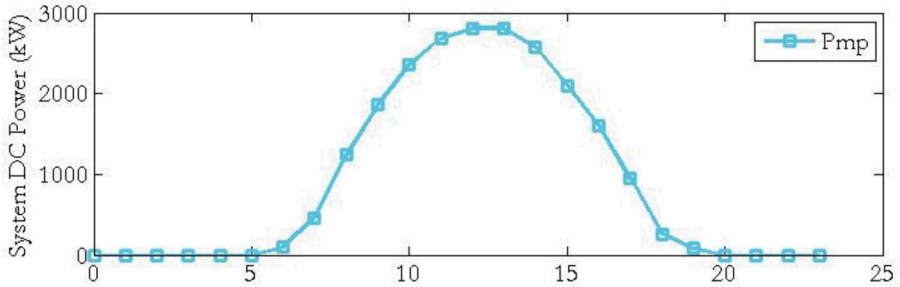
Diagram from Solar Calculator

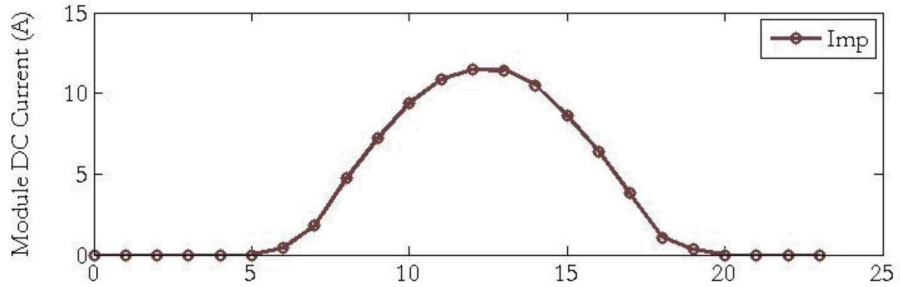
System Performance Analysis

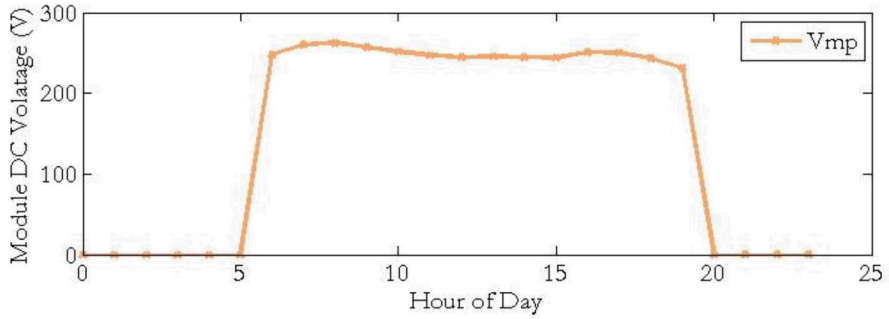
01

- Power Input/Output Optimizations
  - Preliminary System Test 1
    - 10 300W Modules
    - Inverter rated based on 3kW panel input









Conclusions

- Necessity for consideration of home-land-family specificities during sizing process
  - Requires technical evaluation and system design expertise
- Optimal performance and improved efficiency if suited to household
  - Energy production maximized
    - Over production leads to wasted energy
    - Under production leads to lack of energy
  - Resulting in long-term cost savings
- Greater flexibility with choice of PV system components
  - Able to size for future additions due to change of household requirements
  - Future innovations in solar can be included

Native Renewables PV System, Photo from NDN Collective

Next Steps & Future Considerations

01 02 03

- Next Steps in My Research
  - Conduct thorough evaluation of loading requirements per household
  - Determine specific component models for PV systems
    - Consider other technologies such as microinverters, hybrid units, etc.
    - Conduct cost analysis for each system
- Future Considerations
  - Continue process into larger loads
    - Community, commercial scale
  - Investigation into operation and maintenance

NTUA Chinle Office, Photo from Stan

IE Program Overview

- Opportunities to work with many different people and make new connections
  - Site Visits to speak with tribal nations about their projects and their challenges
  - Sandia professionals to walk through system design
  - Native Speaker Series to hear about the experience of Sandia Native professionals
  - Past IE Interns to learn about their solar companies
  - Working with the current interns
- IE Mentor support
  - Making the connections
  - Working on their current projects
  - Sharing their experiences
  - Developing our research abilities

Acknowledgements

- Thank you to the U.S. Department of Energy for sponsoring the Indian Energy Internship Program. This opportunity has been very valuable to my development in understanding renewable energy systems and I appreciate all the resources that were available to me to explore this field.

- Another thank you to our mentors Stan, Julius, Gepetta, and Dylan for supporting all the interns throughout our research. They are one of the main reasons that I enjoyed this program and am inspired to follow their example as strong Native professionals.

Questions?

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