SLATT UNDERGRADUATE RESEARCH FELLOWSHIP
FINAL REPORT

SCHOLAR NAME:	Christina A. Urrea
FACULTY ADVISOR:	Dr. Abigail Mechtenberg
PROJECT PERIOD:	SP2022-FA2023
PROJECT TITLE:	Probability Distributions for Electricity Failures Using Entropy
CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):	**(X) Energy Conversion and Efficiency ( ) Sustainable and Secure Nuclear** **( ) Smart Storage and Distribution ( ) Transformation Solar** **( ) Sustainable Bio/Fossil Fuels ( ) Transformative Wind**

MAJOR GOALS AND ACCOMPLISHMENTS

Summarize your research goals and provide a brief statement of your accomplishments (no more than 1-2 sentences). Indicate whether you were able to accomplish your goals by estimating the percentage completed for each one. Use the next page for your written report.

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Simulate hybrid grid energy systems	via. Homer Powering Health Energy Tool and HOMER Pro. Software	100%
Model entropy increases	via. Python in Google Collaboratory	80%
Model increased risk due to entropy	via. Python in Google Collaboratory	40%
Research Paper	Compile and analyze results	80%

RESEARCH OUTPUT

Please provide any output that may have resulted from your research project. You may leave any and all categories blank or check with your faculty advisor if you are unsure how to respond.

CATEGORY	INFORMATION
EXTERNAL PROPOSALS SUBMITTED	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount)
EXTERNAL AWARDS RECEIVED	(Sponsor, Project Title, PIs, Award Date, Award Amount)
JOURNAL ARTICLES IN PROCESS OR PUBLISHED	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH	(Event, Presentation Title, Presentation Date, Location)
AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT	(Purpose, Title, Date Received)
INTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)
EXTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)
WEBSITE(S) FEATURING RESEARCH PROJECT	(URL)
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail)

RESEARCH EXPERIENCE

Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

FINAL WRITTEN REPORT

(Please use the space below to describe your research project and objectives, any findings and results you can share, and graphs, charts, and other visuals to help us understand what you achieved as a result of this research experience.)

The goal of this research project was to explore the unreliability of electricity in healthcare facilities in Low- and Middle-Income Countries (LMICs). Healthcare facilities with unreliable energy systems face heighted risk for patients whose treatments and procedures require working electricity to save their lives, and further, make decision-making increasingly difficult for practitioners deciding when to begin procedures. In this project, electricity failures were explored via increases and/or decreases in entropy in four types of energy health care systems (EHS). In order to simulate real life changes in entropy that lead to electricity failures, we increased power load so as to simulate an increase in patients being treated or an increase in medical equipment from donations. Lastly, to simulate the decrease of diesel generator use as a means of cutting costs, we created time-limited diesel schedules.

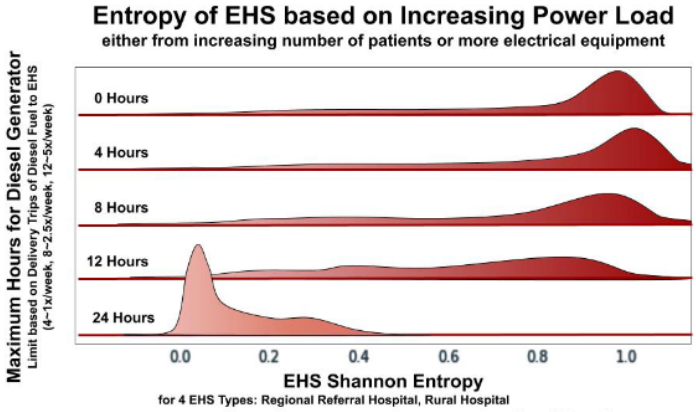

FIGURE 1: ENTROPY OF EHS ON INCREASING POWER LOAD

(Figure taken from *Healthcare During Electricity Failure: Hidden Entropy* by A. Mechtenberg, C. Urrea, L. Omeeboh, M. Ogunlowo, E. Etwalu, L. Nanjula, M. Musaazi, M. Franklin, H. Francois).

Using HOMER Pro. Software, energy grids were simulated for the four EHS types with increasing time-limitations on diesel generator use and increasing power load. The data points for capacity shortage were translated into entropy by assuming a 0 as electricity ON and a 1 as electricity OFF. The density plot shown above in Figure 1 demonstrates how increases in power load, combined with restrictions of diesel generator use, jumped from an entropy of 0, complete stability within the facilities' energy system, to an entropy of 1, complete uncertainty.

Further data analysis demonstrated the unpredictability of energy systems, even with the "acceptable" time shortage of 20%. This unpredictability greatly increases the risk to patients being treated within these facilities and demonstrates an energy inequity experienced by populations in these regions.

The next step for this project is to explore methodologies to alleviate these rises in entropy, particularly within the realm of backup energy sources. Further, to explore how current and future climate changes will further drive this crisis of unpredictability. Lastly, to begin discussions of the ethics of energy disparities and how social inequities have contributed to and will continue to contribute to this energy crisis until properly quantified and addressed.