

Power Sector Innovation: Market Segments

Dr. Destenie Nock

Assistant Professor

Civil and Environmental Engineering | Engineering and Public Policy
Carnegie Mellon University



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graph TD; A[Energy Innovations needed for Increase Social Benefits] --> B[Electricity Access]; A --> C[Unmet Demand];
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Energy Innovations needed for
Increase Social Benefits

Electricity Access

Unmet Demand

Carnegie Mellon University

Perspectives of Energy Transition from Ghana



Developed World

Situation

- Grid is well developed
- Access is unlimited
- System is reliable (hours of outage per year)

Problem

- Minimize:
 - Cost
- Subject to:
 - Demand, Reliability, and Environmental constraints



Developing World

Situation

- Grid is undeveloped
- Access is limited
- System is unreliable (hours of outage per day)
- Demand may be unknown

Problem

- Maximize:
 - Social Benefit
- Subject to:
 - Cost



Ghana Stakeholder Meeting

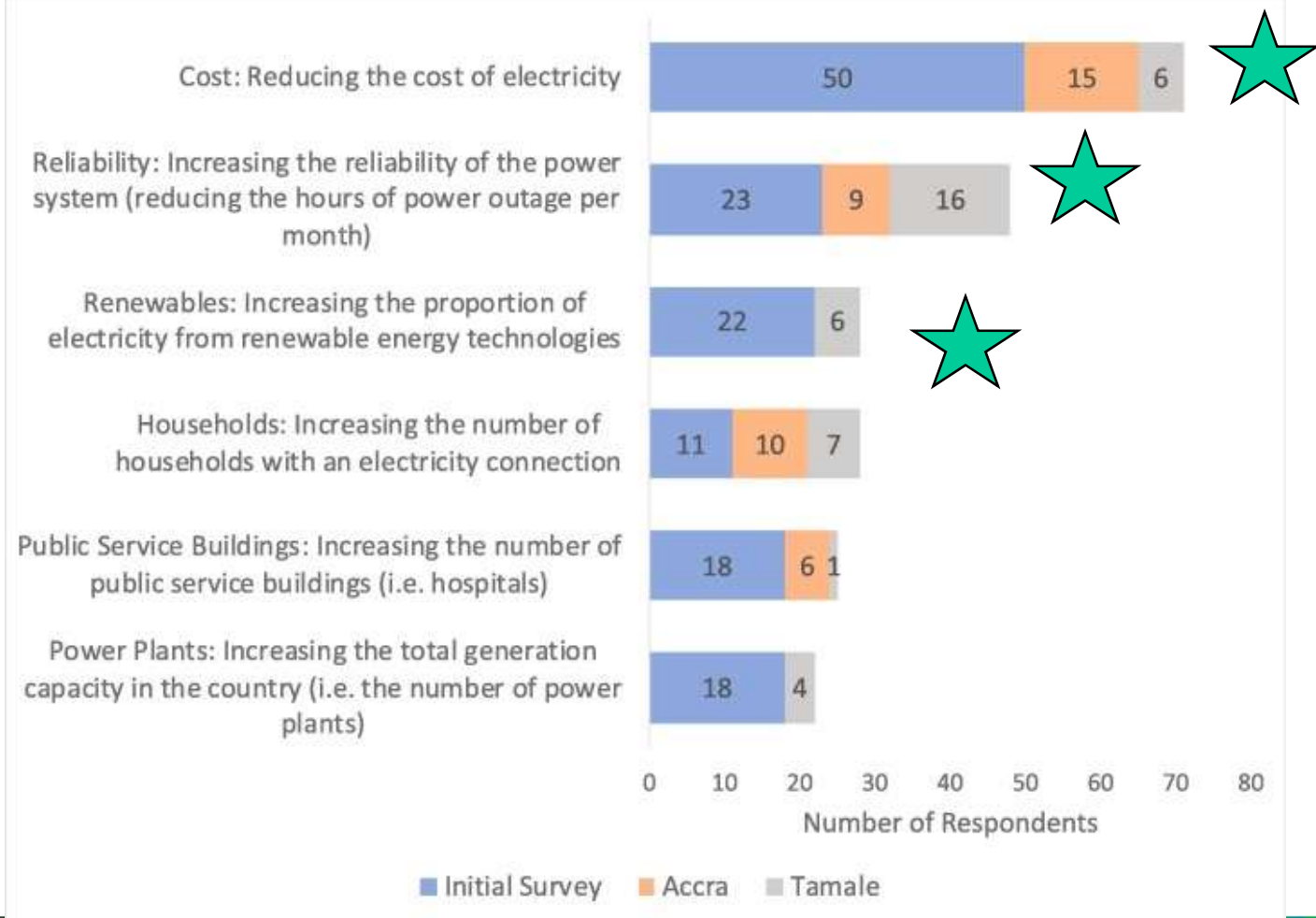


Stakeholder responses to an open ended question on
“challenges facing the Ghana electricity system”



Power System Priorities

- Priorities for improving the quality of life for the people of Ghana through improvements in the electricity system.
- Bars show the number of people who ranked the priority as most important



Need Baseload Renewables

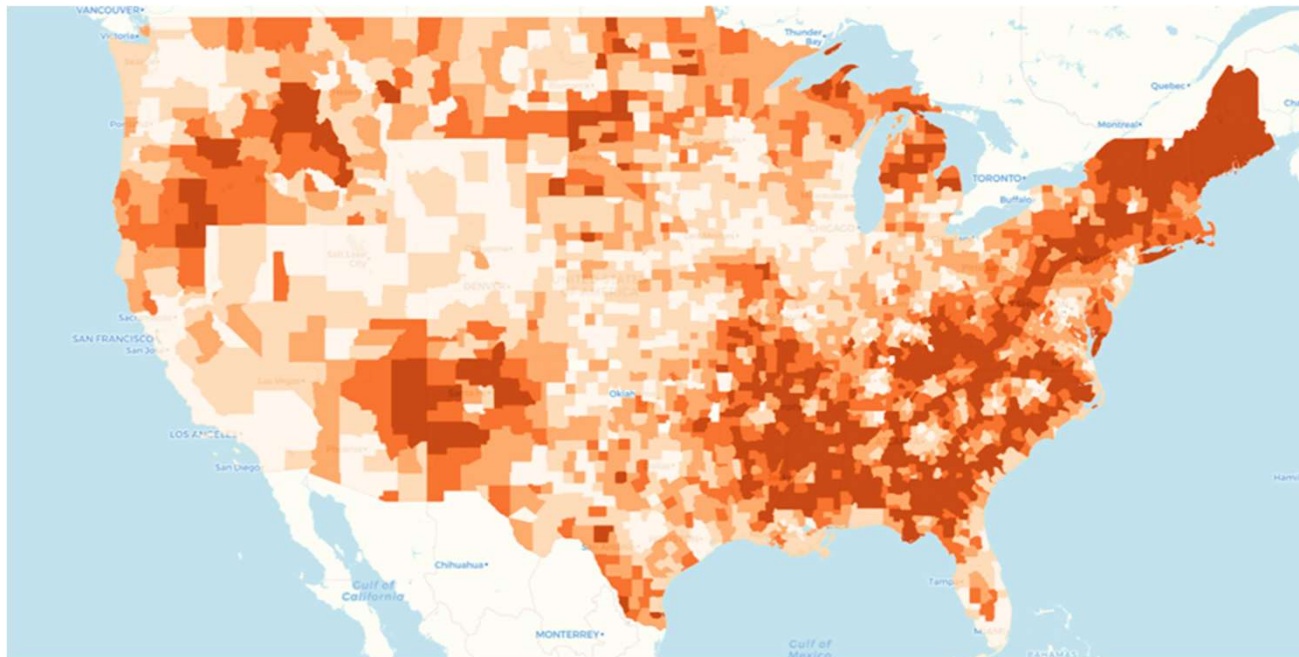
- Stakeholders mentioned lack of manufacturing within the country
- Desire to move away from coal and fossil fuels, but also awareness that need high level of consistent power output.
- Productive uses of electricity (electrifying agricultural sector).



Demand Response Opportunity for Innovation



Energy Poverty in the USA



Energy burdens (at the county level) for LMI (low and moderate-income) households. The lightest color in the choropleth scale is <6% of annual income spent on housing energy bills, and the darkest is >19%.

<https://blog.ucsusa.org/joseph-daniel/how-to-make-energy-burden-less-bad>

Consider Two Households:

- **Household 1 – Income = \$30,000**
- Spends 5% of their disposable income on energy



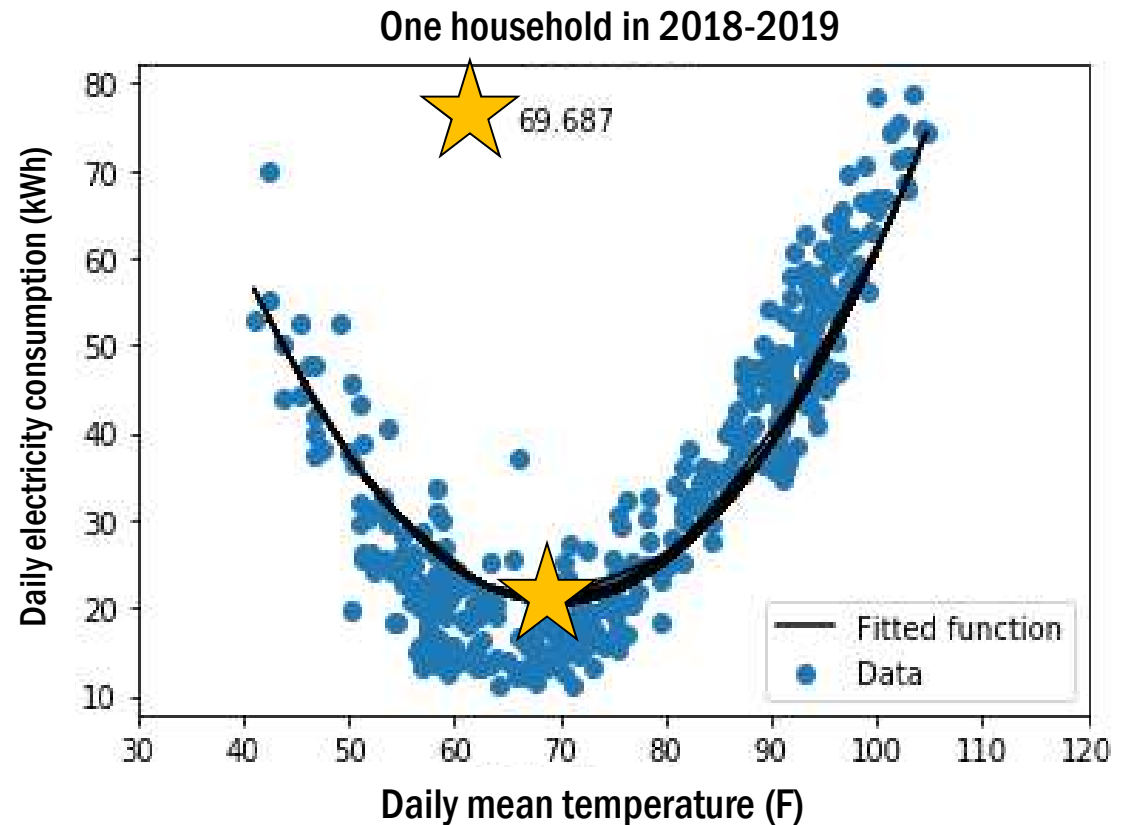
- **Household 2 – Income = \$100,000**
- Spends 5% of their disposable income on energy



Household 1 is shows energy limiting behavior (i.e., reducing their energy consumption to save money)

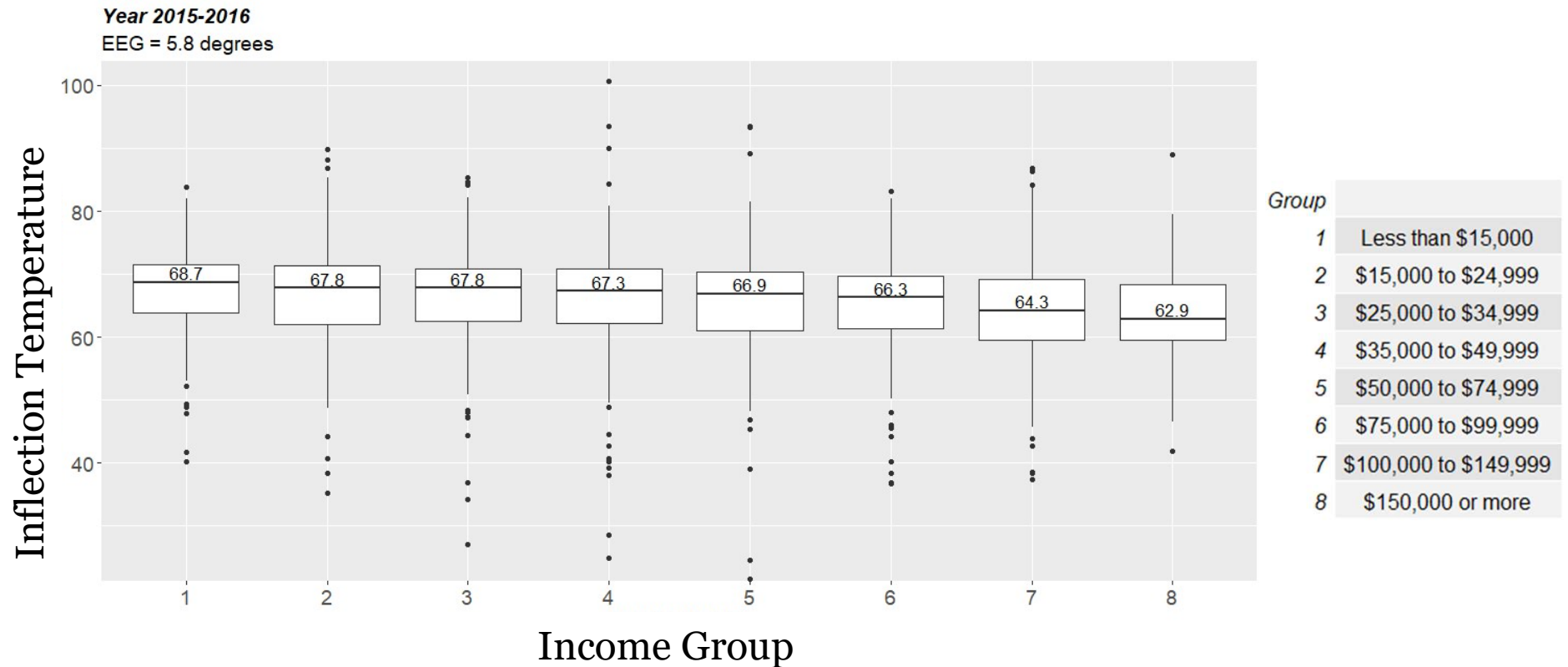
Household inflection temperature

- Inflection Temperature: The temperature at which the household shifts from heating to cooling
- Hypothesis: lower income households will have higher inflection temperatures; lower income households endure hotter indoor temperatures to save money on cooling
- Study Region = Arizona

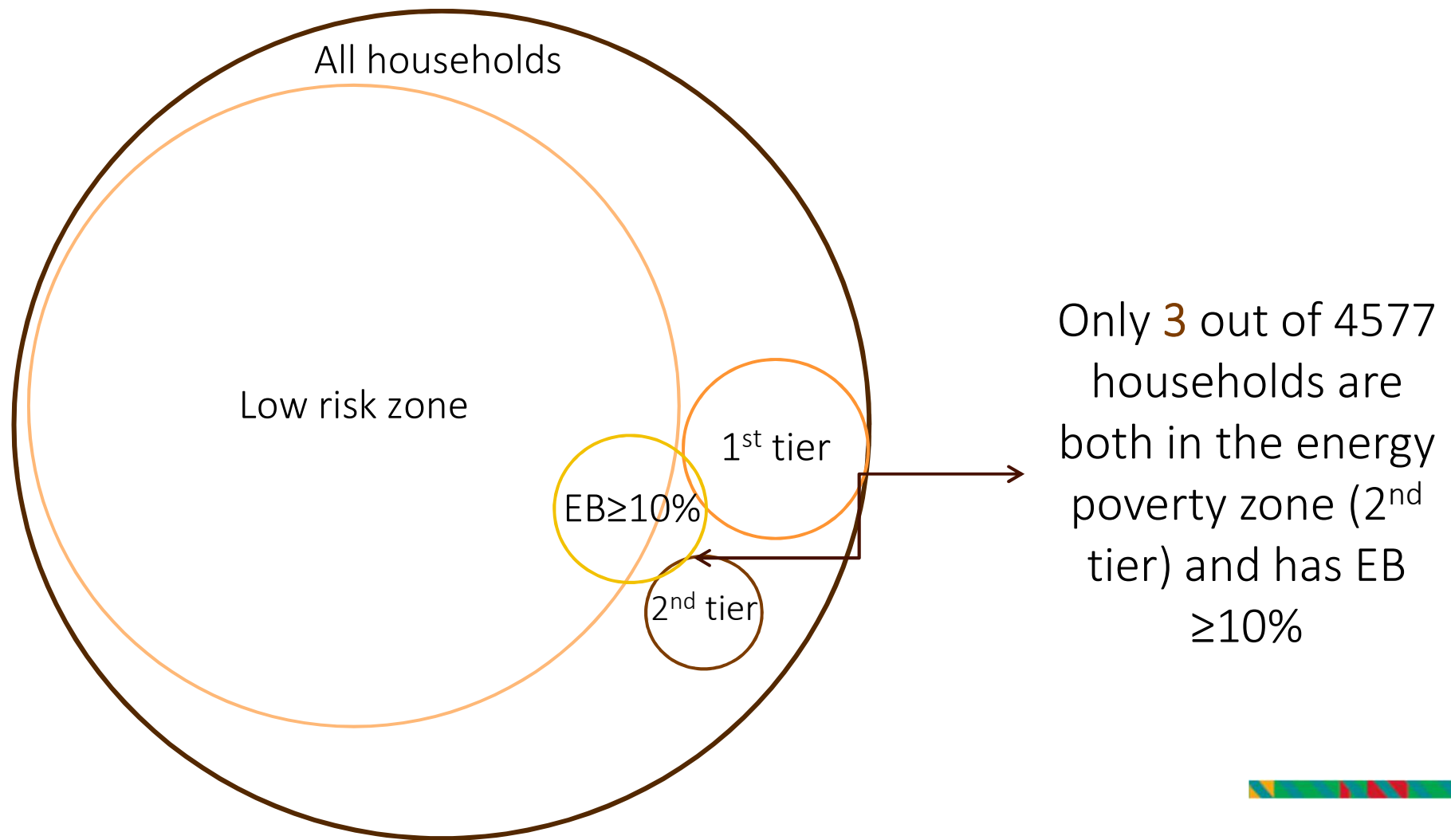


Our metric: The Energy Equity Gap (EEG)

$$\text{EEG} = \text{inf_temp}_{\text{median, lowest-income-group}} - \text{inf_temp}_{\text{median, highest-income-group}}$$



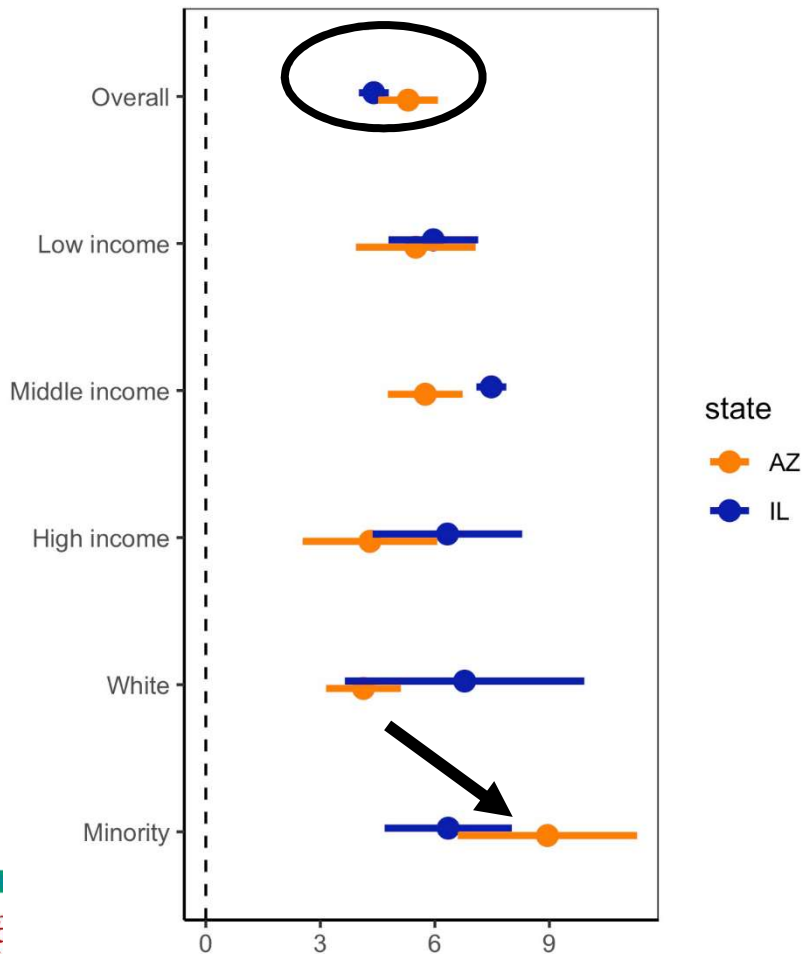
Energy equity gap (EEG) vs. Energy burden (EB)



Representation of the number of households captured by EEG vs EB, 2015-2016

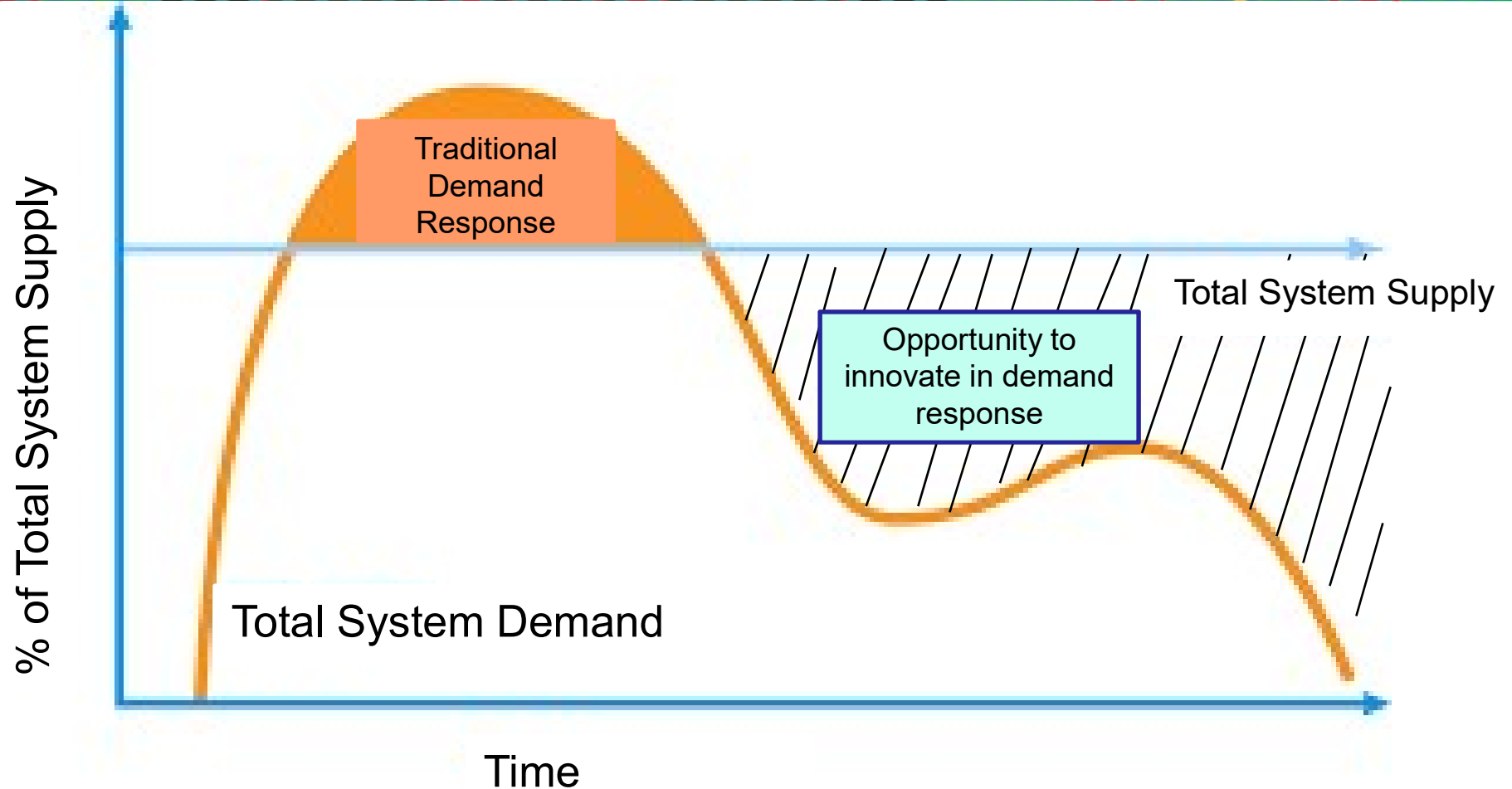
COVID has worsened energy limiting behavior

Percent change in hourly electricity consumption



- If just looked overall we see a 4 – 6% increase in residential electricity consumption
- We see large differences between white and minority groups in AZ which has a large population using electricity for cooling and heating

Demand response for poverty alleviation



Conclusions

- In Africa need more baseload renewables to support productive uses of electricity.
- Need innovation in identifying energy poverty and demand response
- Need to integrate equality into energy system planning.
- Demand response can alleviate energy poverty and help balance out the system.



VS

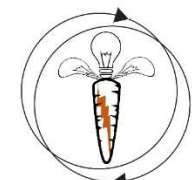


Contact



Dr. Destenie Nock

- E-mail: dnock@andrew.cmu.edu
- Twitter: @DestenieNock



ENERGY, EQUITY
& SUSTAINABILITY

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