

# Sociotechnical Systems to Enable Smart and Connected Energy-Aware Residential Communities

1737591

Panagiota Karava, Purdue

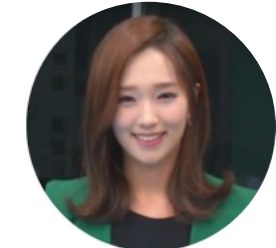
Award Type (IRG), Solicitation Year (IRG-1, FY2017)

## Principal Research Investigators

- *Panagiota Karava (Civil)*
- *Ilias Bilonis (Mechanical )*
- *James Braun (Mechanical)*
- *Thanh Nguyen (Management)*
- *Leigh Raymond (Political Science)*
- *Julia Rayz (CIT)*
- *Torsten Reimer (Communication)*

## Community Partners

- *Jacob Sipe (IHCDA)*
- *Gary Hobbs (BWI)*
- *Roderik A. Watts (BWI)*

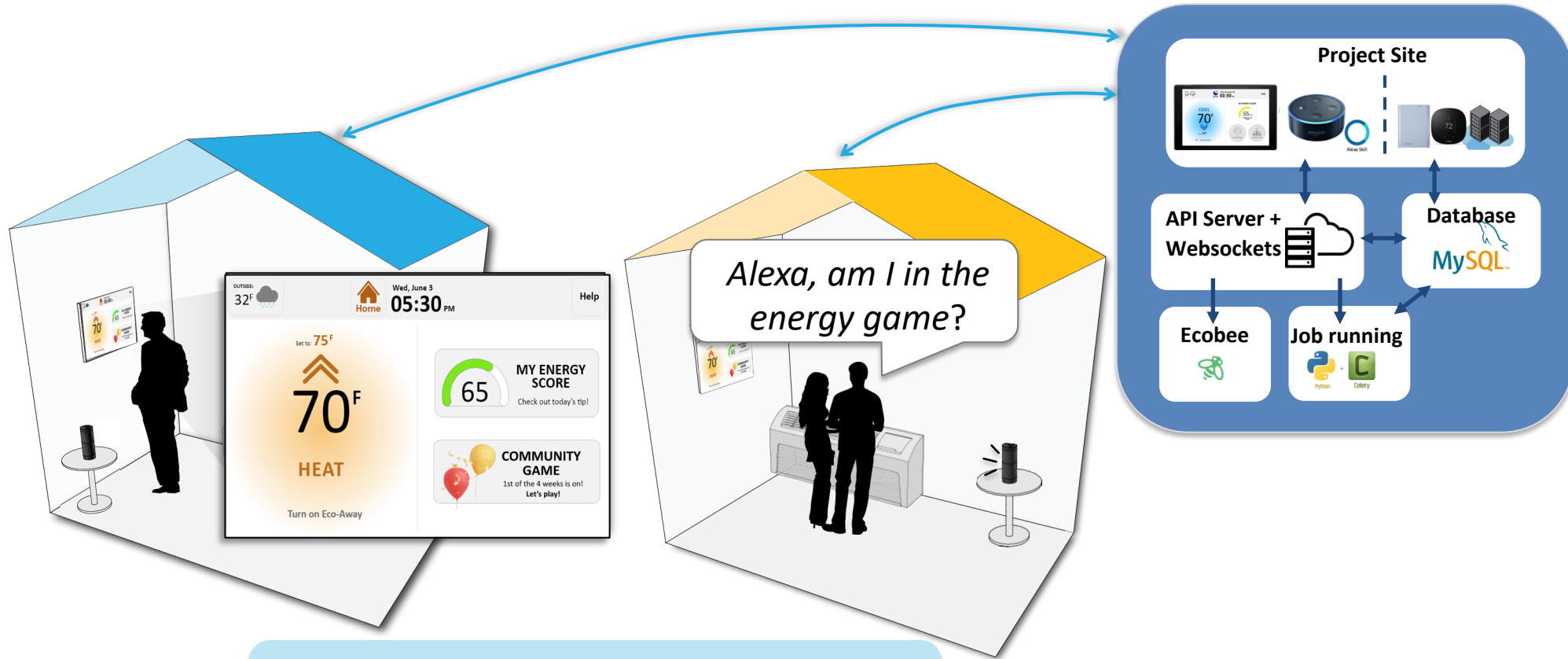


# Project Overview – Vision

**IHCDA:** develops Moving Forward program

**BWI:** builds innovative housing communities

**Purdue:** develops new S&C user-interactive devices



**Our pilot:** Demonstrates SmartE app in 94 Indiana households

- **Our vision:** Realize energy-aware communities that engage residents in understanding and reducing their home energy use
- **Quality of life** improvement in low- and moderate-income households

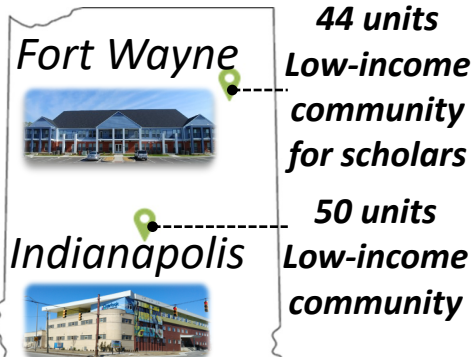


# Project Overview - Use-Inspired Research & Fundamental Contributions

Problem: Housing and transportation costs present a high burden for low income families



Innovative solutions to address the needs of affordable housing communities



Fundamental research

*Physics-informed machine learning for energy model identification*

*Energy-feedback mechanism design*

*Social game design*



SmartE App demonstration



BWI employee

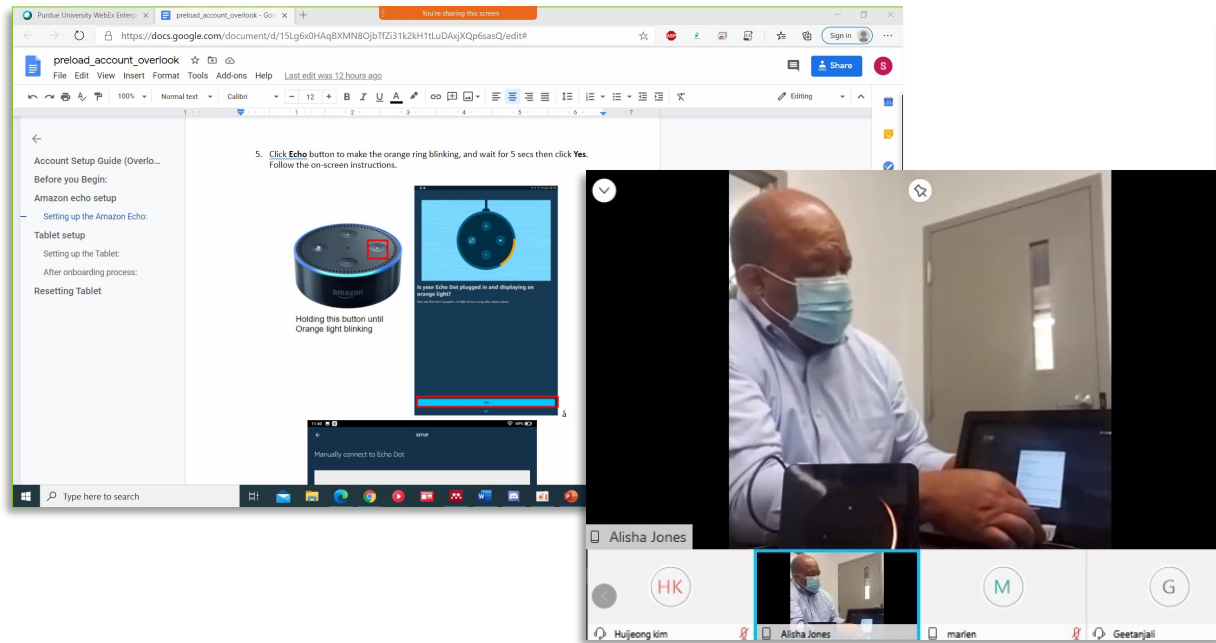


Community resident





# Project Update - Virtual Training & On-site Installation



Online training of the BWI team



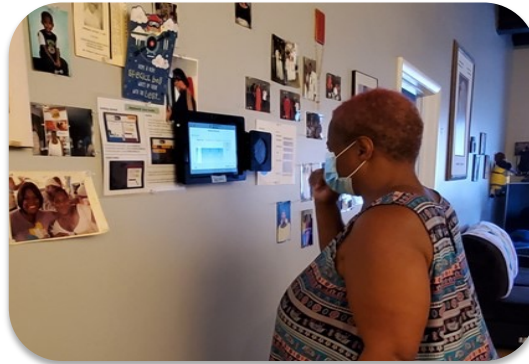
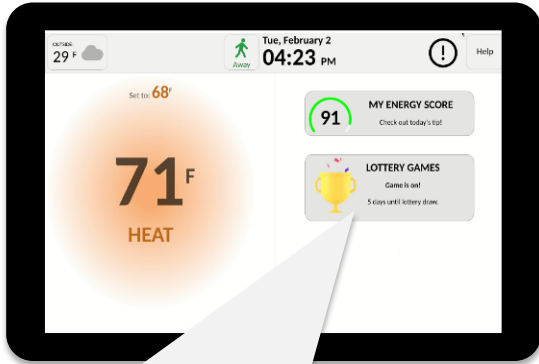
On-site installation and new user onboarding





# Project Update – Lottery Game at Overlook

- Competitive game with \$100 valued bi-weekly lottery
- 30 out of 50 households, Feb 1<sup>st</sup> – March 28<sup>th</sup>



Lottery game example user interface

**Win: \$100**  
1st of 5 Lotteries

**Awesome!** You got 4 of the 4 possible tickets yesterday! Get another 4 today!  
*You have 12 tickets. Check back tomorrow.*

**Lottery Draw is in 2 Days**

**You're in the DRAW**

**BONUS**

**BONUS**

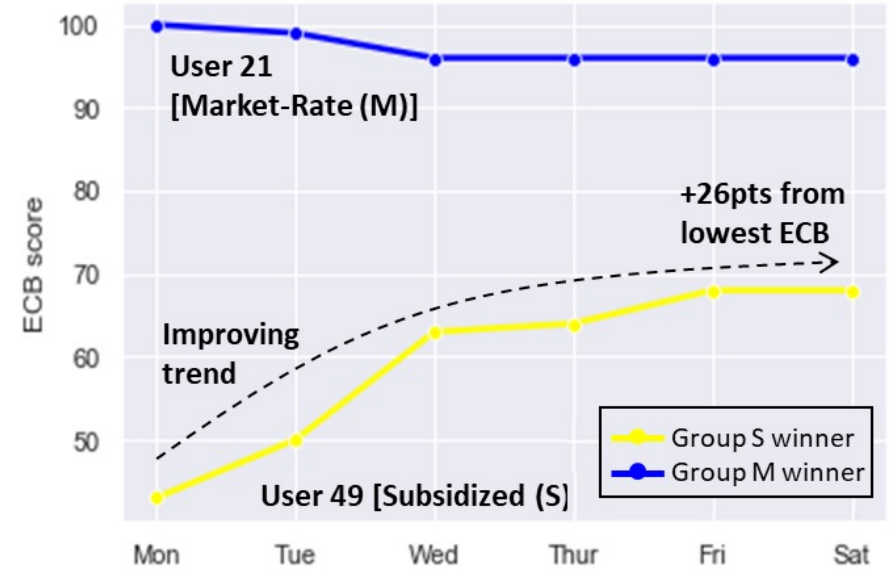
My tickets  Lottery draw participants

Close

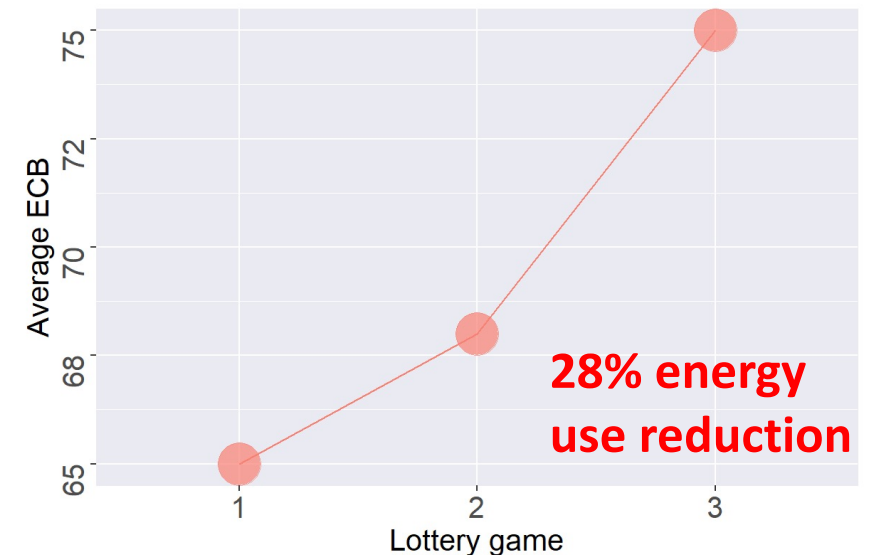
Ask Alexa: "When does the game end?"

See My Daily Tip

Lottery winners performance

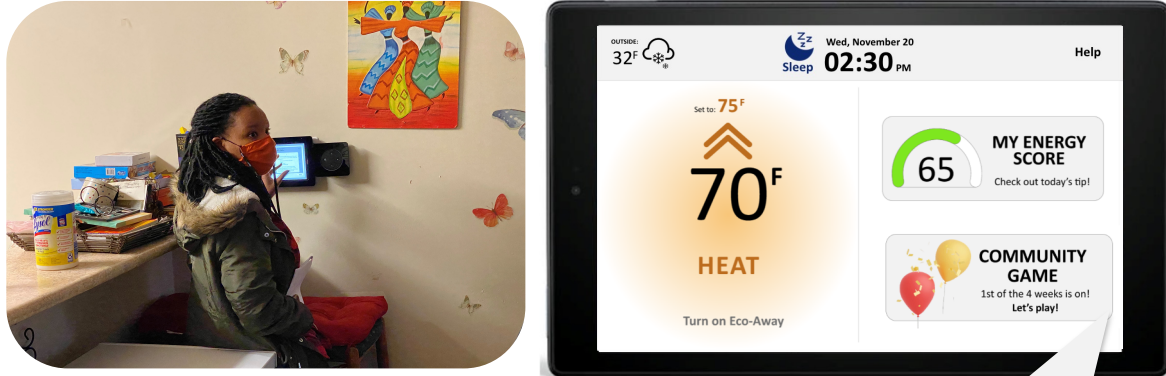


Average weekly community scores



# Project Update – Community Game at Posterity Heights

- Collaborative monthly game with 4 sub-weekly shared goals and rewards
- 27 out of 44 households, Feb 1<sup>st</sup> – March 28<sup>th</sup>



User interface example

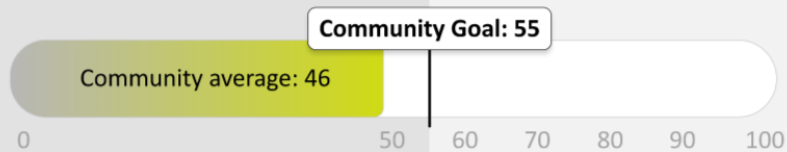
## February Game

Week 2 of 4

You need 5 more points to get in the game.



Your Posterity community has a goal to achieve an average energy score of 55 or more by end of the week.



Your potential reward this week:

\$5



Higher score = Higher reward

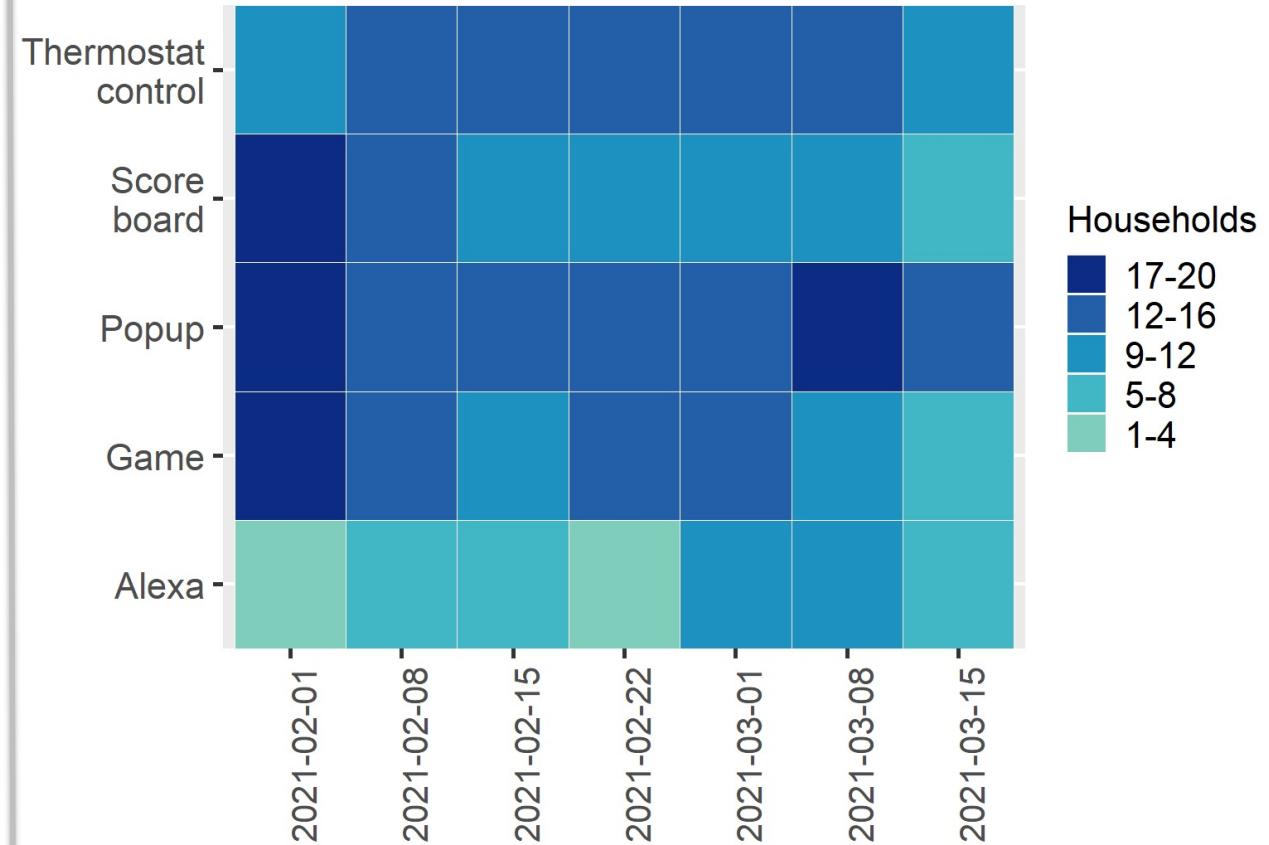
Community goal  Community participation

Close

Ask Alexa: "Tell me the game rules"

See My Daily Tip

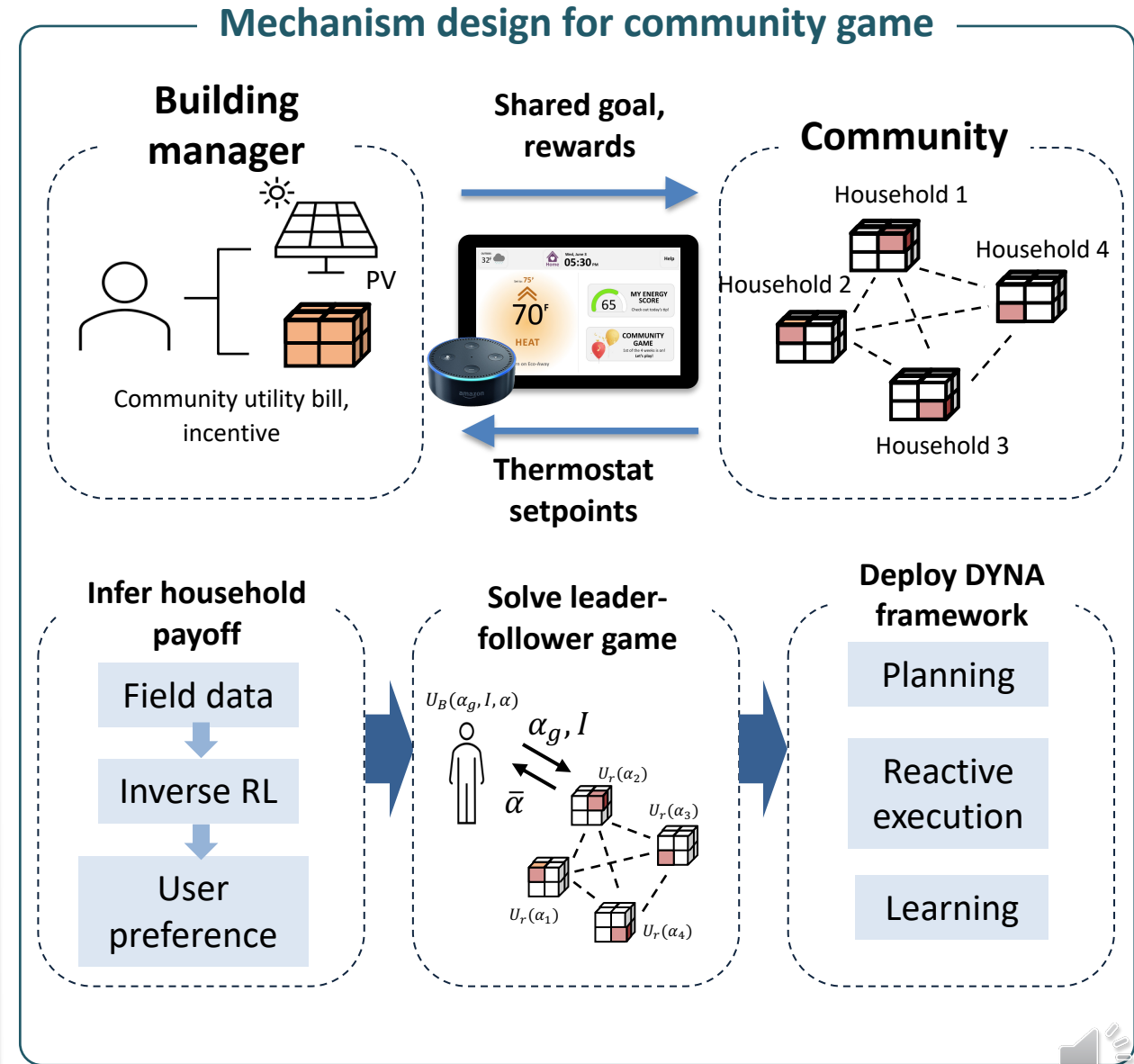
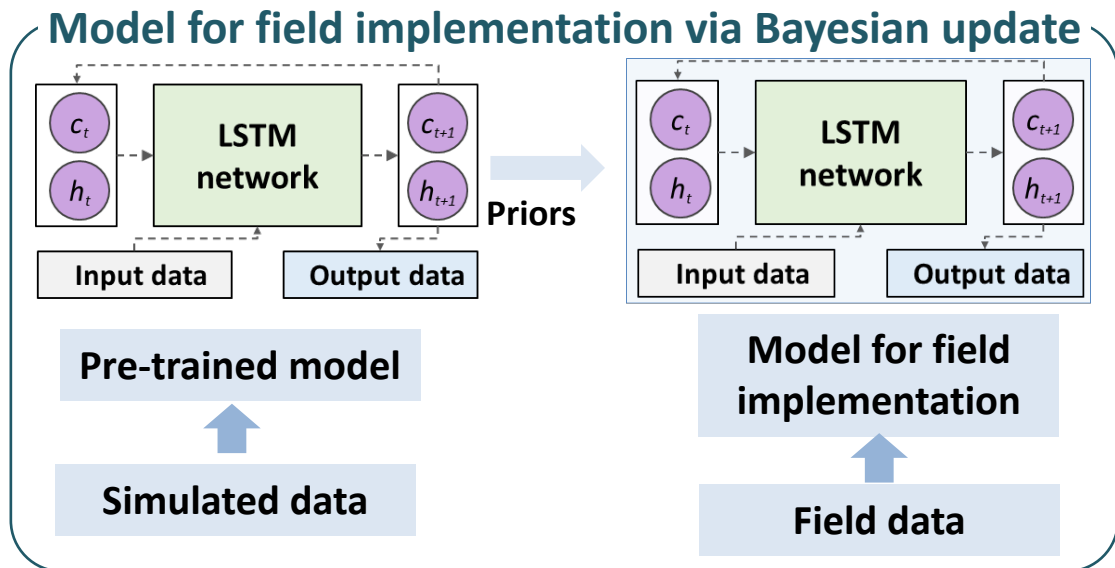
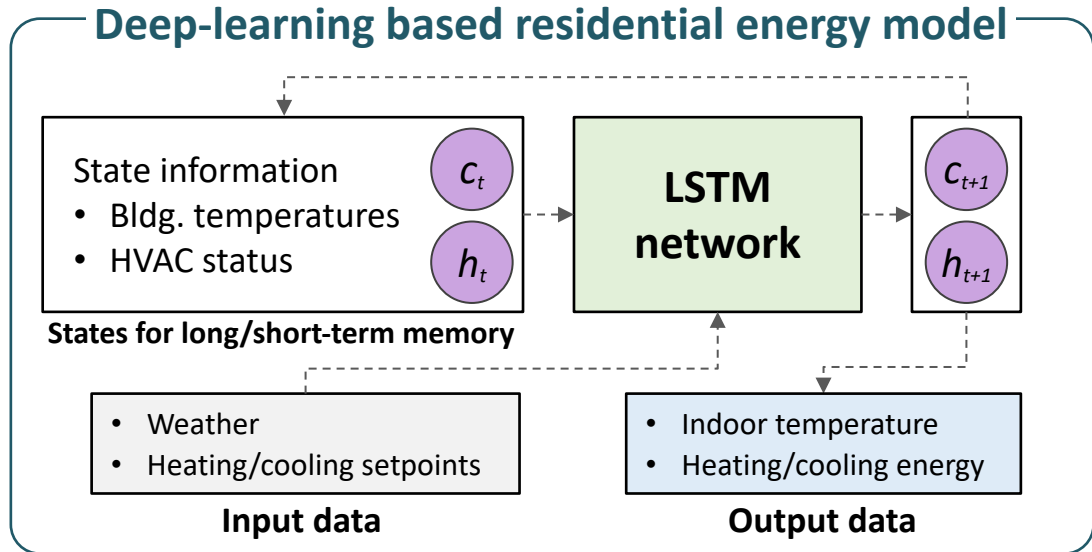
## Weekly user interactions with SmartE App



20% energy use reduction



# Project Update – Sociotechnical Model





# Project Evolution

- *After our first pilot on 2019, we realized that we need to hire a full time software developer to come up with a smart solution for multi-modal device communications (e.g., tablets, thermostats, and smart speakers) and different experimental interventions. So we created a modularized software infrastructure with consolidated API.*
- *We utilized a central WiFi system for smart device communication due to network security and equal opportunity for assessing the devices. But we realized that there is a trade off between the number of WiFi APs (i.e., signal strength) and channel interferences/congestions that require on-site engineering calibration.*
- *We realized that COVID19 may have impacted the behavior and participation of the residents in our field deployment. Therefore, we are conducting careful counterfactual scenario analysis with proper baselines (weather, occupancy) and we also plan to continue the experiments next summer/winter when life would have hopefully returned to a normalcy.*



# Evaluating Project Impact on Communities

- *Cost Savings for the Owner* - Deployment of SmarE resulted in >20-30% energy savings, i.e. >\$3000 utility bill savings during the heating season, for each of the two communities that participated in our pilot study.
- *Improved Quality of Life for the Residents* - Part of the savings are distributed to residents in the form of gift cards, credit in the car-sharing program, and community investments (e.g. new playground).
- *Integrated Data sharing for secondary users* - S&C technology creates an integrated tool to monetize and manage information more effectively (i.e. preventative maintenance, advertisers, manufacturers, etc).

# Anticipated Outcomes & Success Measures for Next Year

- *Evaluate long-term resident engagement, S&C technology adoption, and community impact.*
- *Develop a software platform to optimize incentives and generalize results.*

## Winners

