TRAINING AN AI SMART POWER GRID IN THE CASE OF A DISASTER

Electric Raiders

South Sumter High School

Destiny Williams, Jayley Lewis and Tristan Wiegand

Mentor: Abigail Borgman

Teacher: Stephanie Yarbrough

OUR GOAL

To design a smart grid that will effectively and efficiently distribute power to the most essential users in the event of an outage

KEY TERMS AND CONCEPTS

Users – people, businesses, or organizations that consume energy for various purposes [1]

Essential users – the users that are deemed most necessary in the event of an outage, and are given first priority in energy restoration [1]

Grids – A network of power lines, substations, and other infrastructure that moves electricity from power plants to consumers [2]

Smart grids – electricity networks that use digital technologies, sensors, and software to better match the supply and demand of electricity in real time while minimizing costs and maintaining the stability and reliability of the grid [3]

WHAT ARE MICROGRIDS?

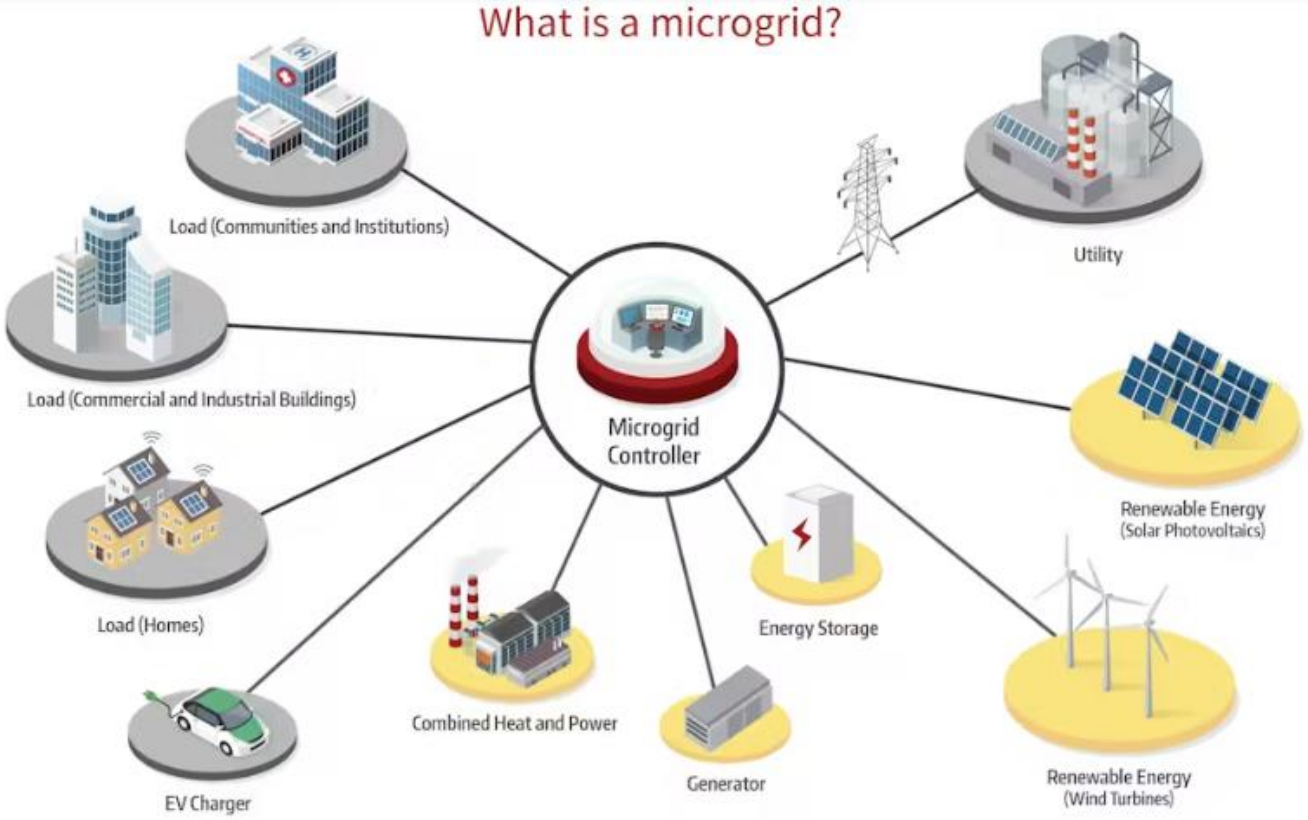


Figure 1. "What is a microgrid?"
Source: [4]

Self-sustained, localized energy systems that serve a discrete geographic footprint and can operate independently or in conjunction with the main power grid

MICROGRID SYSTEMS

- Reliable
- Sustainable
- Efficient
- Economic advantages
- Can run on renewable resources

Figure 2. Our Community microgrid.

WHY USE MICROGRIDS?

- Cost effective
- Supply power to those that have higher priority (schools, hospitals) than those with lower priority (library, post offices)
- Users can unlink their power supply from grids and re-link them
- Micro-grids can consist of island grids and multi-user grids

THE BENEFITS OF USING AI

- More reliable
- Autonomous
- Makes outages less likely
- Efficient
- Safe
- Cheaper than building backup lines
- Best option in the event of a disaster induced outage

PROBLEM/ SOLUTION

Meant to impact power consumption within the community (safe power distribution, strategic power distribution, significantly low cost)

Meant to inform environmentalists, electrical workers, citizens, and micro-grid stakeholders

KEY QUESTIONS

- What are some local power distributers in our community?
- How does power distribution work and how is it measured?
- What is a micro-grid composed of?

PRIORITIZING USERS

User Rank	User Type	How many Users of each type
1	Schools	7
2	Clinics	5
3	Fire Stations	4
4	Grocery Stores	6
5	Gas Stations	10
6	Restaurants	9
7	Hotels	1
8	Post Offices	4
9	Libraries	3
10	Colleges	1

Table 1. Our Prioritized Users

1. Top priority – used as shelters during disasters
2. Top priority – used to help people medically
3. Top priority – used to help people in emergency situations and disaster relief
4. Top priority – used to get food in the community
5. Somewhat priority – used for first responders and residents to get around after a disaster
6. Somewhat priority – used for food if grocery stores or people's fridges are out of order
7. Least priority – possibly used for shelter but unlikely
8. Least priority – used to get mail
9. Least priority – possibly used as shelters or disaster relief buildings as a last resort
10. Least priority – used for education but not essential

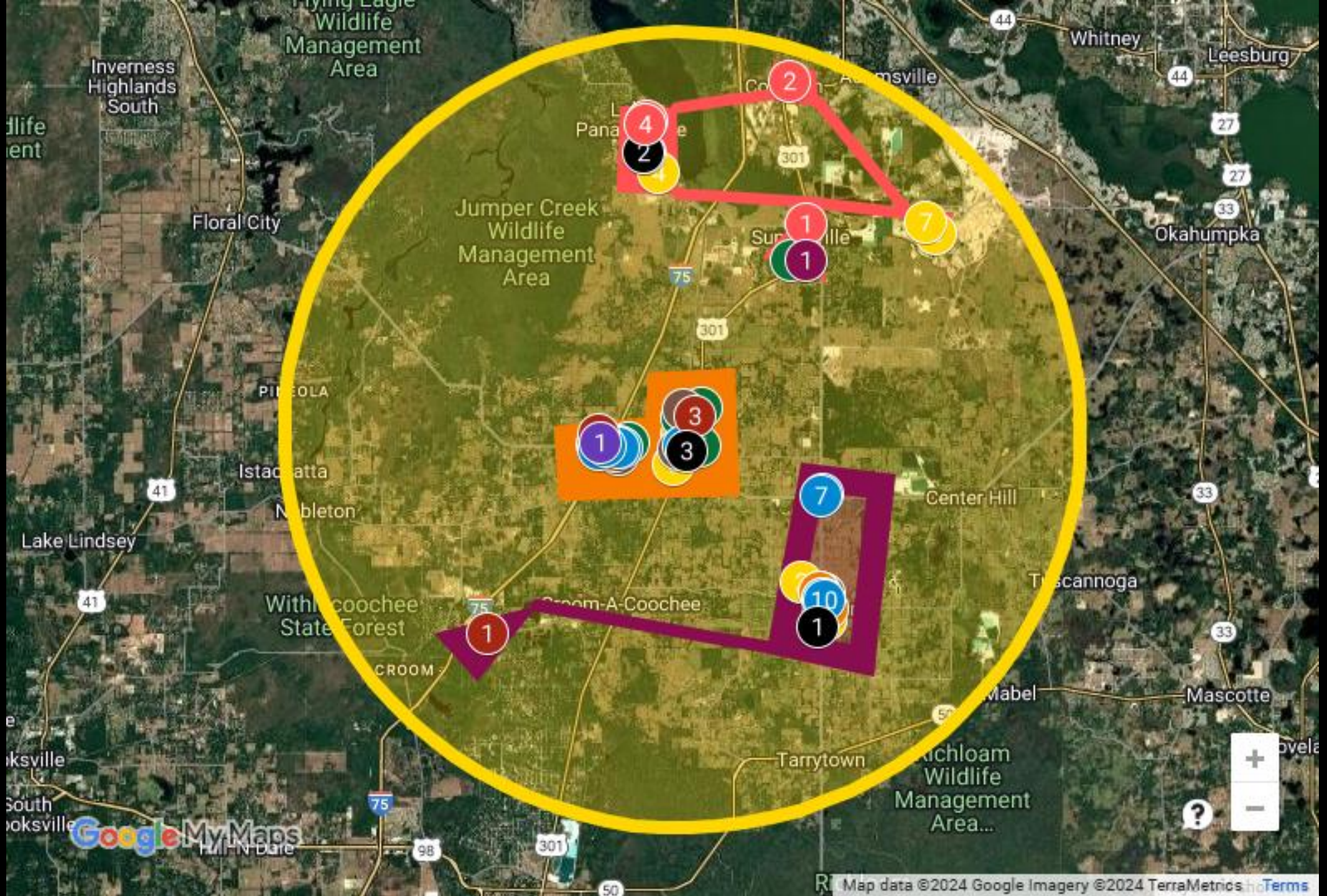


Figure 2. Our Community microgrid.

DAILY ENERGY USE (TOP PRIORITY)

X- axis: time of day

Y-axis: energy expenditure in kWh

Note: y-axis is differently scaled for each user

Data for no outage

Peak usage at midday for all users

Lowest usage about 12 a.m. for all users

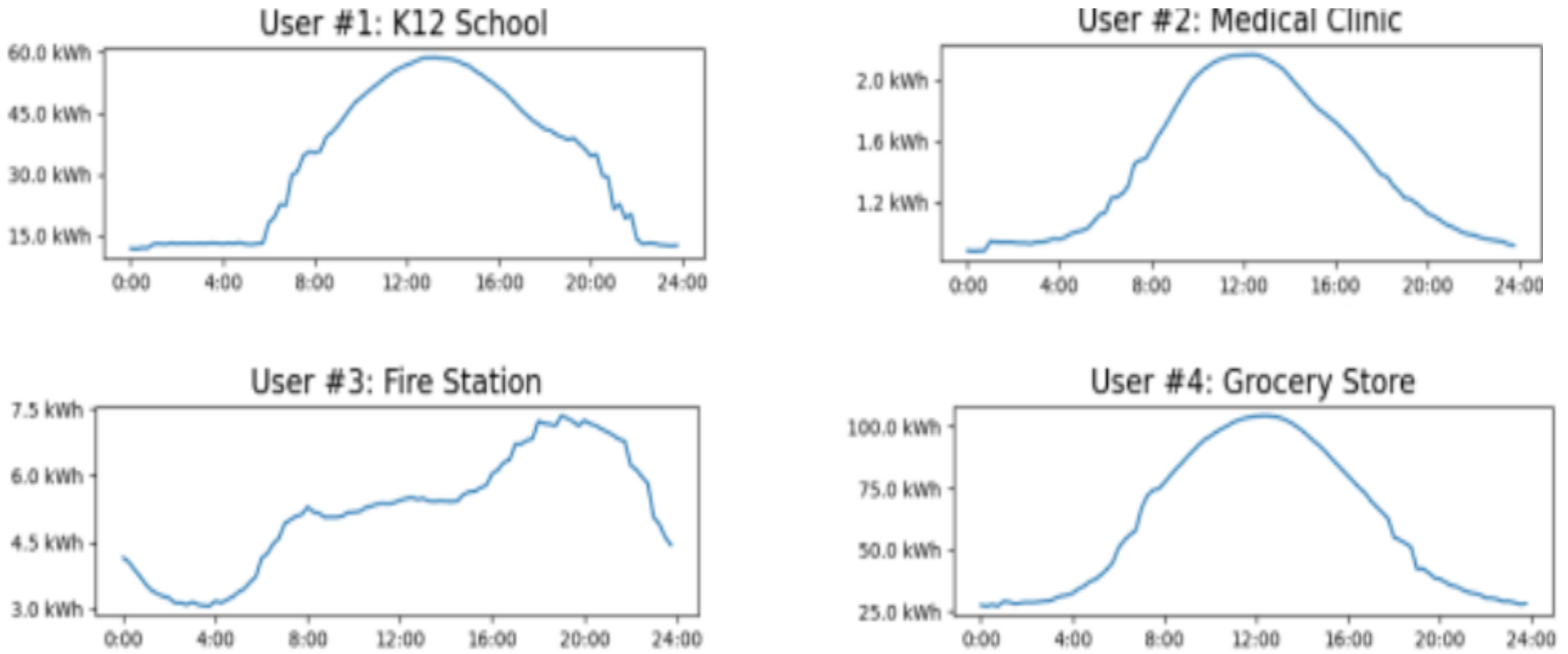


Figure 3. Daily Energy Use with no Outage.

DAILY ENERGY USE (SOMEWHAT PRIORITY)

X- axis: time of day

Y-axis: energy expenditure in kWh

Note: y-axis is differently scaled for each user

Data for no outage

Peak usage at midday for all users

Lowest usage about 12 a.m. for all users

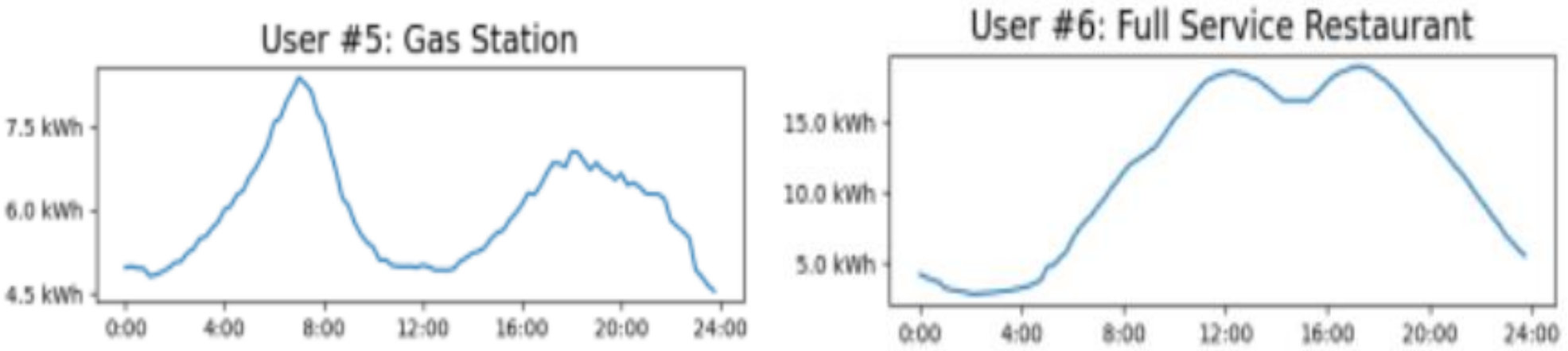


Figure 3. Daily Energy Use with no Outage.

DAILY ENERGY USE (LOW PRIORITY)

X- axis: time of day

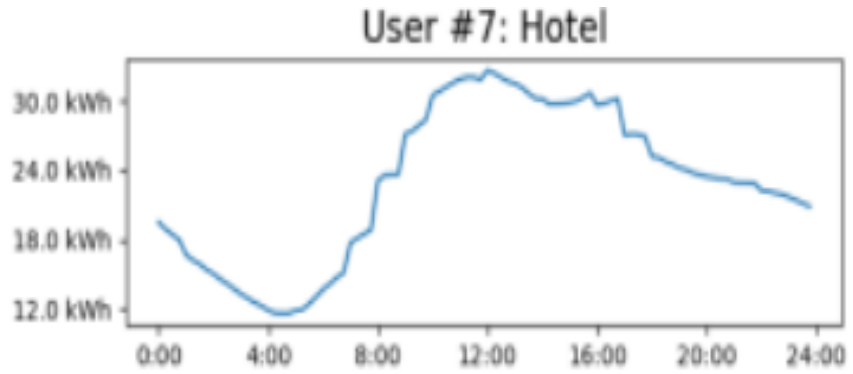
Y-axis: energy expenditure in kWh

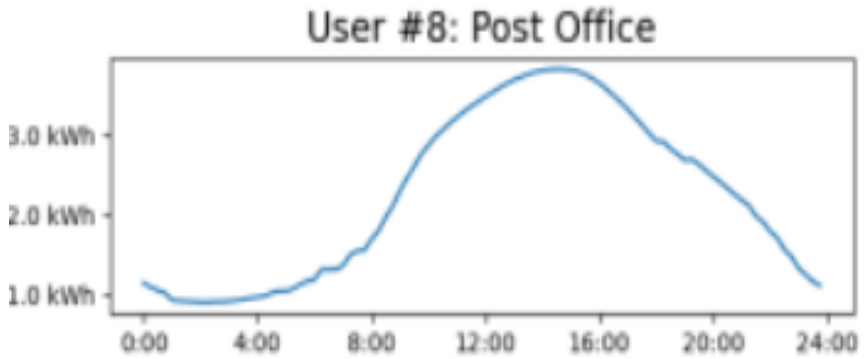
Note: y-axis is differently scaled for each user

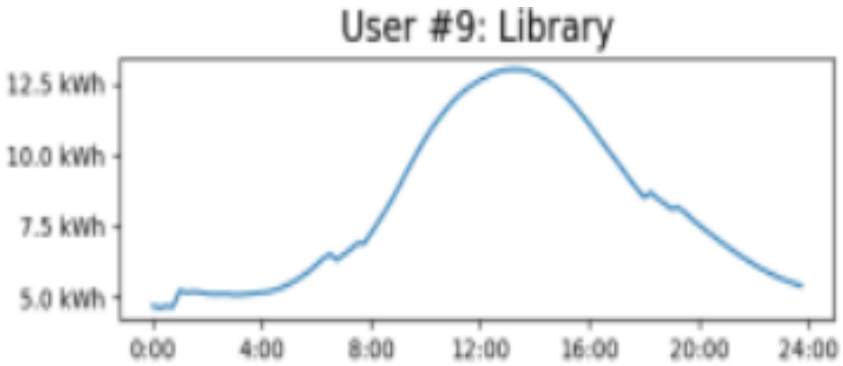
Data for no outage

Peak usage at midday for all users

Lowest usage about 12 a.m. for all users







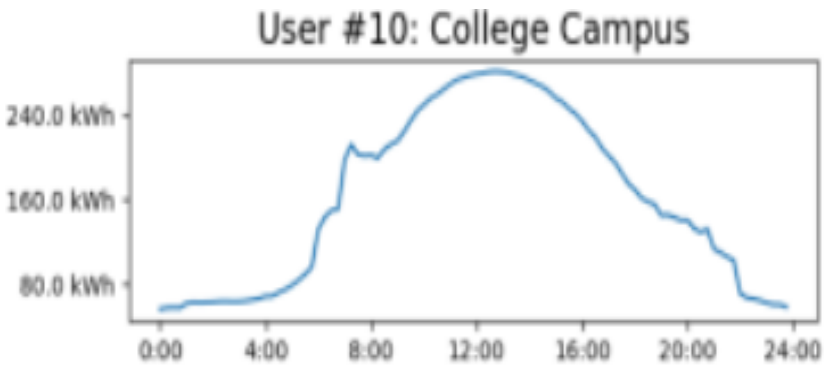


Figure 3. Daily Energy Use with no Outage.

YEARLY ENERGY USE

X- axis: time of day

Y-axis: energy expenditure in kWh

Note: y-axis is differently scaled for each user

Relatively similar to the daily data, and show that during quarter two in a yearly cycle, all users use similar amounts of energy due to the temperatures rising and more electricity being expended on AC.

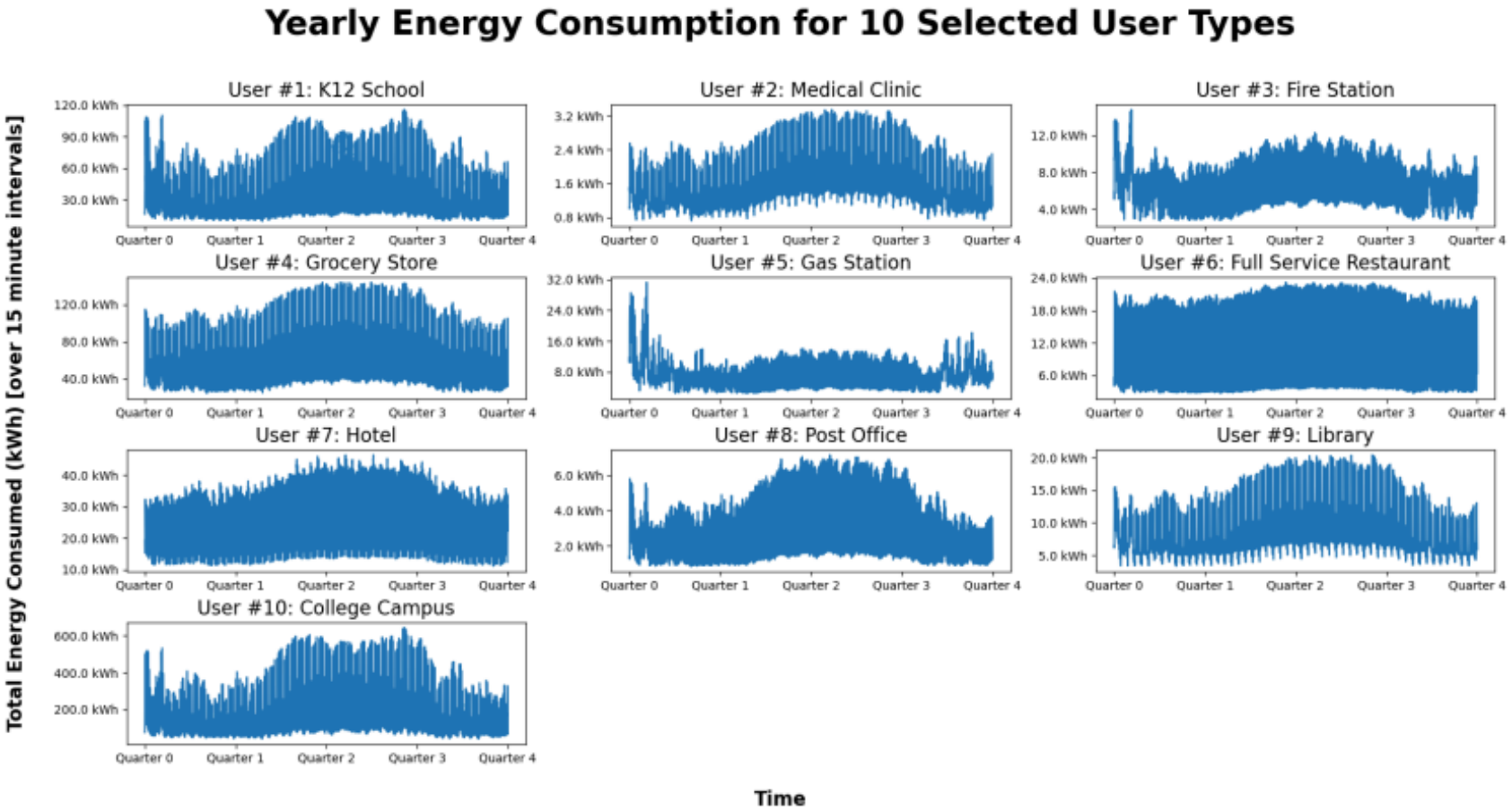


Figure 4. Yearly Energy Use with no Outage.

How does the AI model work?

User Name	Normal Max Power 12A-12A (kW)	Normal Power Distribution (%)
User 1: K12 School	1644.6	24.2
User 2: Medical Clinic	43.3	0.6
User 3: Fire Station	117.5	1.7
User 4: Grocery Store	2507.6	36.9
User 5: Gas Station	335.6	4.9
User 6: Full Service Restaurant	681.2	10.0
User 7: Hotel	130.6	1.9
User 8: Post Office	61.3	0.9
User 9: Library	156.3	2.3
User 10: College Campus	1124.1	16.5
Total (kW)	**6802.0**	**100.0**
DISASTER MAX POWER (kW)	**4081.2**	
(60% Normal Max Power)		

Figure 5.
Training the AI Model

WHO GETS THE MOST POWER AND WHY?

Top priority users such as schools, clinics, and fire stations receive the most amount of energy.

Energy allocation decreases with user priority

During peak use hours, about midday, some lower rank users receive no power, while high ranked users receive their needed amount

During low use hours such as the middle of the night, all users can receive their needed electricity usage

USING AI TO OPTIMIZE POWER DISTRIBUTION

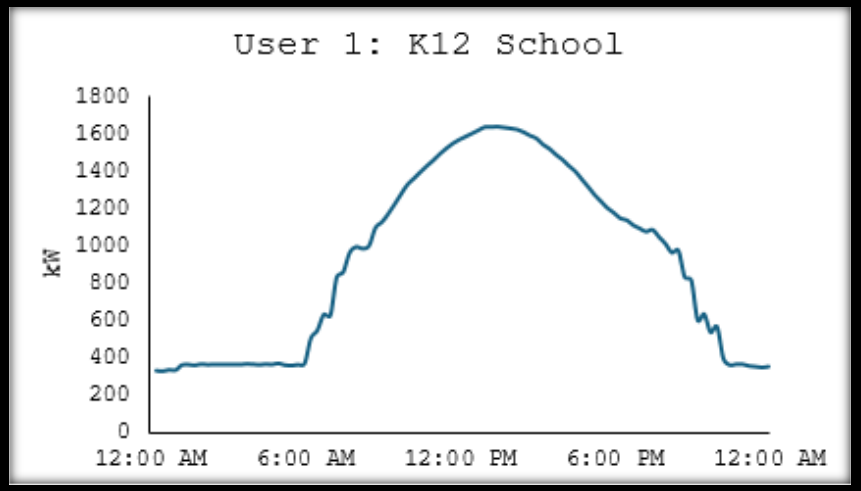


Figure 6.
School daily energy use without restriction

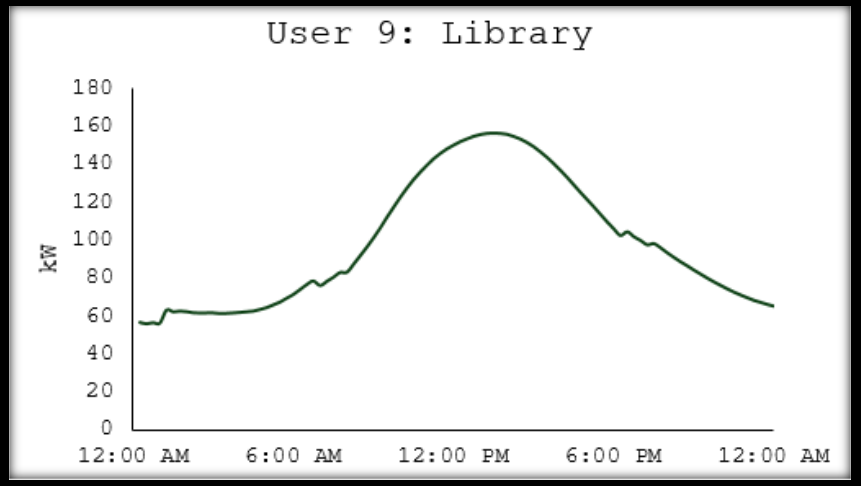
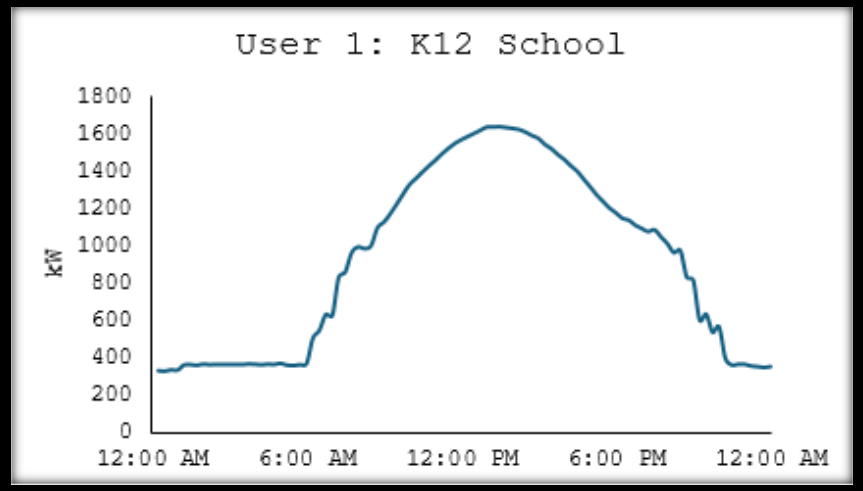


Figure 7.
Library daily energy use without restriction

USING AI TO OPTIMIZE POWER DISTRIBUTION



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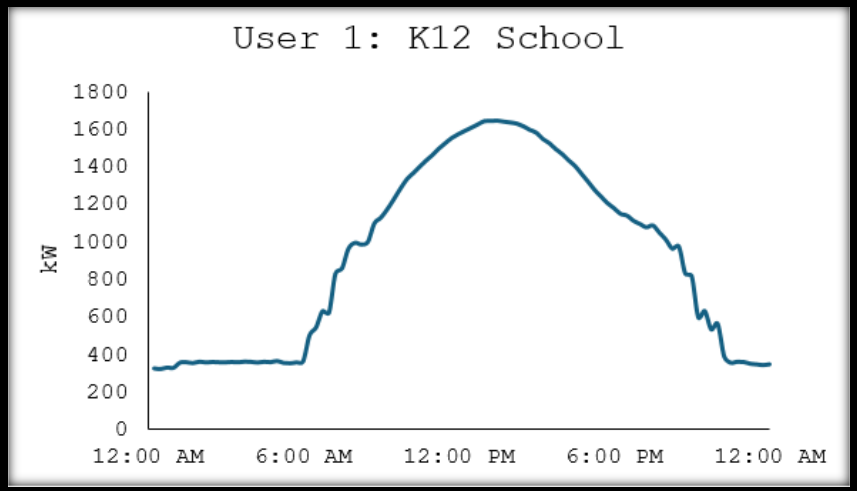

Figure 8.
School daily energy use with restriction

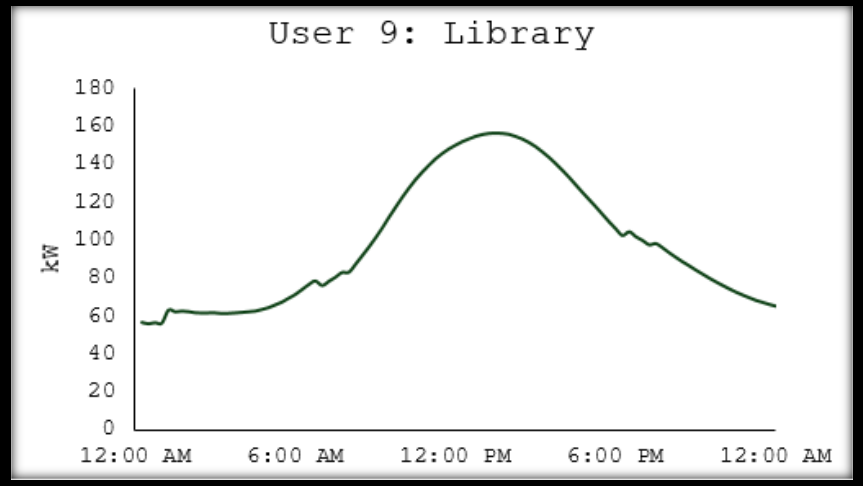

Figure 7.
Library daily energy use without restriction

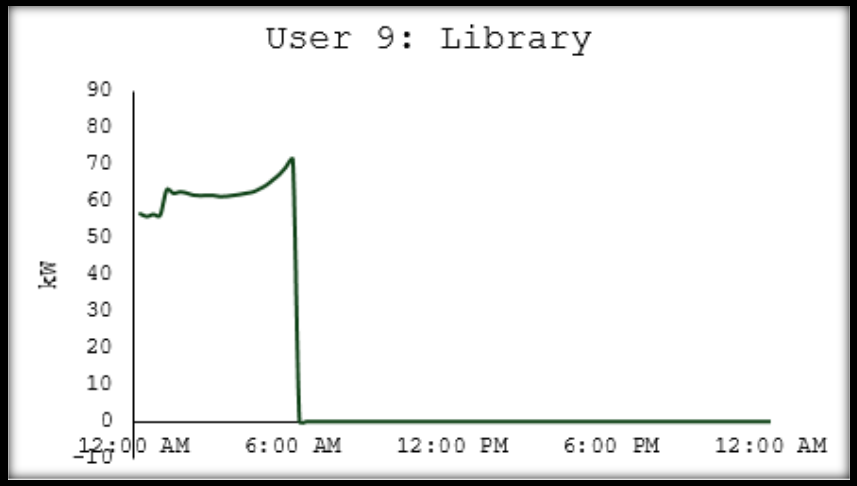

Figure 9.
School daily energy use with restriction

WHY ARE MICROGRIDS IMPORTANT?

After the recent hurricane Helene, nearly 4 million homes and businesses were without power in Florida, Georgia, South Carolina, and North Carolina.

-Power Grid International [5]

MICROGRID DESIGN

Organized by:

Geographic Location

Service Area

User business type and rank

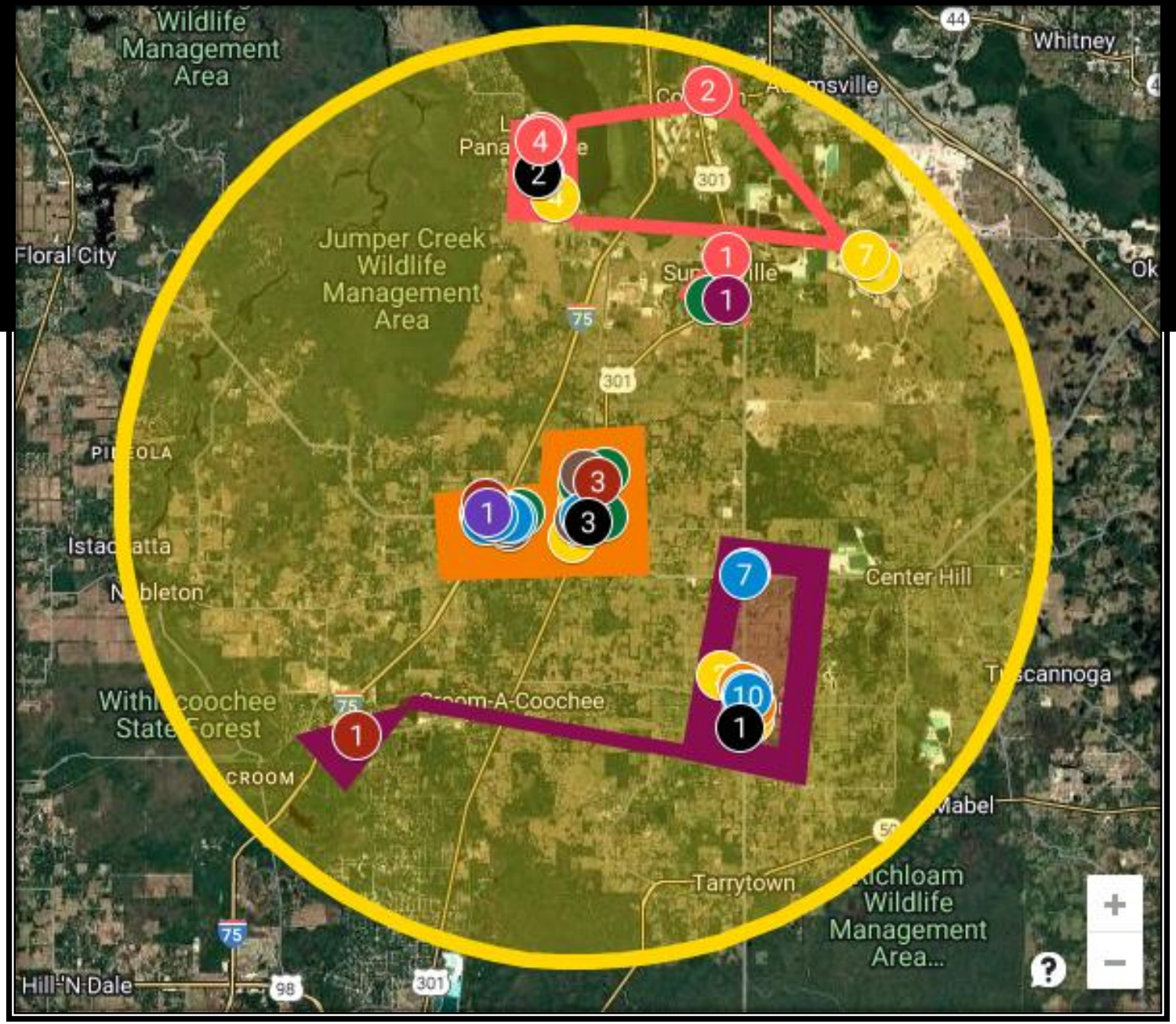

Figure 2. Our Community microgrid.

WHY US?

"The microgrid will support grid operations and provide backup electric power to the school when it must operate as a special need's hurricane evacuation shelter. The project enhances electric service and grid operations for customers."

-Duke Energy [6]

WHY US?

"The primary resilience benefit of microgrids is their ability to disconnect from the main grid when there is an outage and operate autonomously. This ability to continue serving critical loads, such as medical facilities or grocery stores, can mitigate the social and economic costs of disruptive events."

- *Grid Deployment Office, U.S. Department of Energy [7]*

REFERENCES

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[2] "How does the U.S. Power Grid Work?," Council on Foreign Relations, https://www.cfr.org/backgrounder/how-does-us-power-grid-work

[3] Lea, "Smart grids," IEA, https://www.iea.org/energy-system/electricity/smart-grids (accessed Nov. 15, 2024).

[4] Image on slide 4. E. Wood, "What is a microgrid?," Microgrid Knowledge, https://www.microgridknowledge.com/about-microgrids/article/11429017/what-is-a-microgrid

[5] C. E. C. Directors, "Millions without power across nine states after Helene makes landfall," POWERGRID International, https://www.power-grid.com/td/outage-management/millions-without-power-after-helene-makes-landfall/ (accessed Nov. 8, 2024).

[6] "Duke Energy Florida announces three new battery storage sites, including special needs shelter and first pairing with Utility Solar," Duke Energy | News Center, https://news.duke-energy.com/releases/duke-energy-florida-announces-three-new-battery-storage-sites-including-special-needs-shelter-and-first-pairing-with-utility-solar (accessed Nov. 8, 2024).

[7] Microgrid Overview, https://www.energy.gov/sites/default/files/2024-02/46060_DOE_GDO_Microgrid_Overview_Fact_Sheet_RELEASE_508.pdf (accessed Nov. 8, 2024).

FIGURES AND TABLES

THANK YOU!

QUESTIONS?