Pilot Case Study:

ElectricFish's battery microgrid integrated EV charger

350^2

1358 Abbott St, Detroit, MI 48826

Oct 2022 - May 2023

in partnership with

ElectricFish

1. Executive Summary

ElectricFish Energy, Inc. is a technology company which builds and deploys clean, resilient energy infrastructure to support the diverse energy needs of disadvantaged communities. In partnership with DTE Energy and the International Brotherhood of Electrical Workers (IBEW) Local 58 chapter, it installed its microgrid, a battery integrated EV charging station, at a public site in the DTE Energy service area, funded through the Michigan Mobility Funding Platform (MMFP) Real World Deployment Grant. The site, the IBEW Local 58 Zero Net Energy (ZNE) Center, is Michigan's first Zero Net Energy facility.

The pilot project began on October 24, 2022, with a goal of demonstrating the capacity to service both retail consumers and an enterprise customer in a hybrid use case within the DTE utility service territory. The project was completed in partnership with *DTE Electric, IBEW, Black & Veatch* and *NextEnergy.*

ElectricFish's resilience-first technology, to accelerate the electrification of transportation with its patented battery-integrated electric vehicle extreme-fast charging (XFC) stations, **the 350^2.** As well as offering DC Fast Charging for electric vehicles, ElectricFish's storage-integrated EV charging station also utilizes the company's proprietary optimization engine, **the Stargazer,** to help the site host (IBEW Local 58) manage their energy usage and reduce peak demand.

By using onsite generation, such as solar panels or a small-scale renewable energy system, the site can offset its energy needs and potentially lower its overall energy costs. This innovative solution not only provides a convenient and reliable charging option for EV drivers, but also supports the host's sustainability efforts and helps to limit the impact of fast charging on the distribution system.

"We have piloted multiple charging and storage technologies, and of all those, ElectricFish's product has been the most impressive and resilient."

- **Andre Crook, IBEW Local 58**

Table 1: Summary of pilot objectives and outcomes

Objective	Status	Results
Rapid and low cost installation	✅	5 days / ~$10,000
Support utilization of on-site renewable generation	✅	~18kW solar
Demonstrate time-of-use load management	✅	time of use shifting
Deliver electric vehicle fast charging sessions	✅	>150 charging sessions
Deliver power outage support and charging*	❌	Not demonstrated
Demonstrate reliability support to distribution system**	⚠️	Work in Progress

* systems required manual reboot during outage event with manpower unavailable in time

*** DTE meter delivery and install delayed*

2. Contents

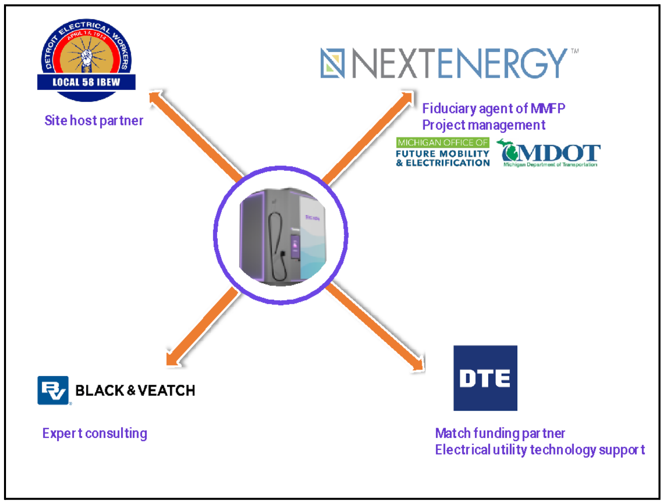

Figure 1: ElectricFish MMFP Deployment pilot partners

3. Project Partners

In addition to the MMFP grant award, our partner utility DTE Electric contributed matching funding in the form of cash cost share, while ElectricFish provided the hardware system as a temporarily leased asset for the term of the demonstration. Black & Veatch also provided services for project engineering drawings and documentation. At the end of the real-world deployment project, IBEW verbally agreed to purchase the system at an early adopter discount while also developing a strategic channel partnership to develop business for ElectricFish in Southeast Michigan.

4. Pilot objectives and metrics

The objectives of the project were to deploy microgrid-integrated EV charging station at a public site in DTE Electric service territory:

- quantify the value of resilience generated for DTE's distribution system,
- support site host's ability to use onsite generation to support electrical load during non-generation hours, using excess generation during high radiance hours,
- demonstrate ability to support mission critical EV and site operations with our stations serving as flexible resiliency hubs,
- validate the value and scalability of ElectricFish's technology in Michigan

The results summarized in Table 2 are discussed through the rest of this report.

Objectives	Key performance metrics	
Rapid installation and commissioning	Order- to-deployment timeline	**23 weeks**
	Post-delivery activation timeline	**5 days**
Low-cost installation	Total installation cost	**$10,526**
Demonstrate building load management and support	Electricity delivered in low-/no- solar generation hours	**68 kWh**
Deliver electric vehicle fast charging sessions	Number of payment transaction EV charging sessions delivered	**80 sessions**
	kWh of paid EV charging sessions delivered	**660 kWh**
Demonstrate service reliability	System uptime	**99.95 %**

Table 2: Summary of pilot objectives, key performance indicators, and system performance metrics

5. Introduction to Technology

Figure 2: ElectricFish unit deployed at IBEW Local 58's Zero Net Energy Center with Stargazer™

5.1 The 350squared

The ElectricFish flagship 350squared integrates a 350-kWh battery with a 350-kW capacity EV DC fast charger. The system provides faster Level 3 charging (350 KW) that can provide up to 170 mile EV range charging in 10 minutes, and also also serve as a distributed grid asset by bi-directionally providing power to the local site and grid. This cuts peak loads of extreme-fast-vehicle charging and can improve the performance of the electricity grid in areas such as reliability, uptime, and efficiency.

The major technical breakthrough of this solution is its ability to be deployed at a rapid pace, taking weeks in permitting and installation as compared to years for a conventional DC Fast charger or Microgrid service.

5.2 Stargazer

The 350squared is configured to strategically charge and discharge at optimal times to reduce demand charges with the help of ElectricFish's proprietary optimization engine - Stargazer. It considers the current and forecasted demand for electricity, as well as the available supply of electricity from the grid and any on-site generation sources. Using the previous year's IBEW site load profile, Stargazer leverages the power of time series forecasting and generates a prediction dataset to estimate next year's IBEW site load profile.

Pilot System Specification Sheet	
Battery energy storage	
Battery Chemistry	Li-ion (NMC)
Storage Capacity	200 kWh
Depth of Charge	0.95
Electrical specifications *(input)*	
AC Power	≤ 18 kW
AC Voltage	240 VAC (± 15%) split-phase
Current	120 Amp OCPD
Frequency	50 / 60 Hz
Electrical specifications *(output)*	
AC Backup Auxiliary Output	120 V
DC Charging Output Voltage	300-950 V
Maximum DC Output Current	500 Amps
Voltage Accuracy	± 2%
Current Accuracy	± 2%
Maximum DC Output Power	350 kW
Short Circuit Rating	Designed for 10kAiC
Cooling System	Liquid-cooled
Physical Specifications	
Dimensions (H × W × L)	8 ft × 8.5 ft × 10 ft
Enclosure Material	Galvanized steel
Cable Reach	2.5 m / 8.2 ft
Weight	6,200 kg / 13,670 lbs
Environmental specifications	
Enclosure Rating	IP54 / IK10 (to be tested); NEMA 3R
Installation Location	Outdoor
Ambient Operating Temperature Range	-20°C - 70°C
Seismic protection	Optional Bolting - rating 2 (to be tested)
Interfaces	
Charge Ports	1 port
Supported Connector Types	CCS ISO15118, DIN 70121
Display	15" TF T-LCD
Push Buttons	Emergency Stop
User Authentication	OCPP, Square Payment
Protection	
Galvanic Isolation	Transformer
Isolation Monitoring	IS0425
Stop Switch	External, daisy chained
Fire safety	Designed for UL9540
Certification	
Inverters	UL1741 SA, Rule 21
EVSE	Built for UL2202
Battery Pack System (Dec 2022)	For UL1973, UL9540, UN 38.3
Connectivity	
Communication	4G / LTE
Interface	CAN / RS485 Ethernet
Grid Interface	ADR 2.0b

Figure 3: ElectricFish MMFP Pilot system specifications

Using Markov Chain Monte Carlo sampling techniques from the open-source Prophet algorithm, Stargazer also accounts for uncertain trends in seasonality, such as freezing Detroit winters and warm summers. To reduce extreme predictions, Major Event Days (M.E.Ds) are withheld from the dataset by removing outliers from the data. This ensures that the optimization algorithm only prioritizes conservative predictions so as to not overload the power grid. Stargazer connects with the 350squared system's onboard AC-DC control mechanism to store electricity during times of low demand and then discharge it during times of high demand. By doing so, the need for additional power generation or the use of more expensive forms of generation can be avoided, which can help to reduce energy costs and improve the overall efficiency of the local distribution grid.

5.3 Cybersecurity Threat Monitoring

The proposed pilot is in partnership with a California based Cybersecurity firm, IPKeys Cyber Partners. They are a leading nationwide provider of cybersecurity and critical infrastructure protection technology and solutions throughout North America. IPKCP provides quantitative results enabling ElectricFish to make business-justified investments for relevant security programs. IPKeys Cyber Partners provides ElectricFish with end-to-end capability of Cyber Security Monitoring, Cyber Vulnerability Assessment, patch management and remediation services to the California Mobility Center community.With this partnership, IPKeys Cyber Partners provides 24x7 Cyber Security monitoring and vulnerability assessment coverage and analysis with recommendations for mitigation, as well as reports and analysis from IPKCP Subject Matter Experts (SME) on threats facing the 350squared system.

6. Deployment and installation

Demonstrating reproducibility of rapid deployment value proposition was a key objective of this pilot project. The deployment and installation of typical fast charging systems takes between 6-18 months, with installation costs for comparable DCFCs upwards of $100,000, with a recent study finding installation costs of $400,000-$800,000 in California EV corridors for 350 kW fast chargers.

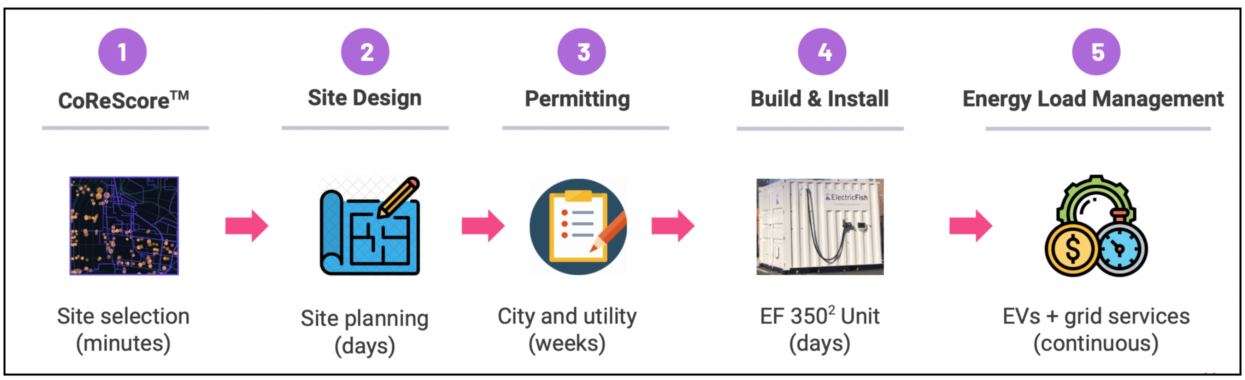

Figure 4: ElectricFish value proposition on deployment process and timeline

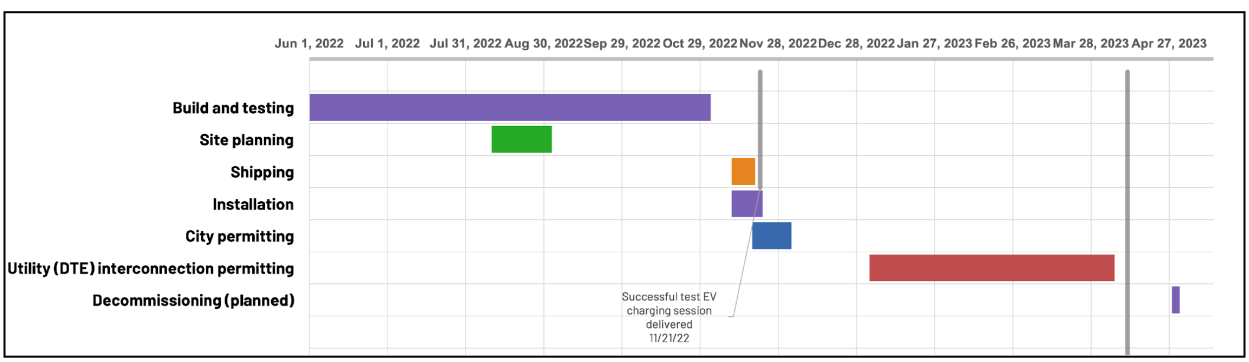

Figure 5: Pilot demonstration project timeline

6.1 Pilot deployment timeline

The pilot unit took 23 weeks in total to build and deploy, from initiation to commissioning. Figure 4 breaks down the deployment process, with a hardware build lead time of 20 weeks, site planning process of 3 weeks, municipal permitting taking 1 week, shipping in 1 week, and installation taking 5 days, with the delivery of first EV charging upon commissioning on day 5.

	Details	Invoiced expenses
Shipping	Fremont to Detroit trucking	$6,928.00
	Trucking fuel surcharge	$2,026.00
	Rigging for loading	$1,848.00
	Rigging for unloading	$1,648.00
Insurance	Insurance premium payment	$1,950.99
Installation	Electrical permitting and installation	$8,575.00
Maintenance	Liquid replenishing	$80.00
	AC-DC converter replacement	$900.00
	Grounding rods and other upgrades	$263.94
	Labor cost for maintenance	$1,323.00
	Labor cost for upgrades	$1,200.00
Administrative	Travel	$1,004.97
	Lodging	$1,454.91
Total	**$29,202.81**	

Table 3: Itemized shipment, installation, and maintenance cost

6.2 Deployment and installation costs

It **cost $10,526 to permit, install, and insure the system**, demonstrating our capacity to cut installation costs for EV-DCFC systems by up to 90% with our system architecture. We have been able to reproduce this low-cost installation value delivery for a second time, the first being at a previous demonstration in downtown Los Angeles with the LADWP. Shipping accounted for 43% of the $30,000 deployment cost, which we consider to also include maintenance over the 6-month demonstration period. Table 3 itemizes these costs by category and activity, with their proportional contribution depicted in Figure 4.

7. DER Operational Analysis

The response of the EF system to rapid grid strain events during DCFC sessions at IBEW 58, notably on Mondays and Tuesdays, demonstrates ElectricFish's potential to tackle the challenges linked with fast electric vehicle charging. By mitigating sudden grid strain, promoting energy efficiency, and fostering greater grid independence, our combined solution signals a promising stride towards sustainable energy management. These findings underscore the transformative potential of our solutions in shaping the future of energy use and management.

7.1 Successes and Failures

Fast Launch: We were able to launch the unit in just 2 days.The EF system requires no effort from the host site to operate, removing the need for tasks like setting up credit card machines or handling cash. This convenience factor minimizes the burden on host sites and makes our system an attractive option for future deployments.

EV Charging: Our system is designed to accommodate most electric vehicles, showcasing its versatility and wide-ranging applicability. The charging process is incredibly user-friendly, with users able to initiate a charge in an average of just 15 seconds. This quick and easy interface enhances the user experience, encouraging further use of EVs. The system generated revenue through the sale of over 600kWh of energy, which demonstrates the potential for our EF charger to serve as not just a sustainable solution, but also a profitable one.

<u>Internal system temperature regulation:</u>
Figure 5 represents the system's internal temperature profile for 3 weeks, represented by 6 temperature sensors placed at various key points in the system. These frequent, sudden temperature drops are caused by opening and exposing the system to outside temperatures. These relative peaks are caused by the heater turning on. The system can experience fluctuations in external temperature due to open exhausts, testing, open doors, etc. If the internal temperature drops below 15 degrees Celsius, the heater will try to regulate the temperature. As a byproduct, the heater blows hot air into the sensors which increases the recorded temperature for a few moments.

Aside from the explained outliers, note that the internal temperature is <u>well regulated at 15 degrees celsius.</u> In the varying and often extreme weather conditions found in Detroit, the 350squared is able to maintain a consistent and appropriate internal temperature, regardless of the exterior temperature. This helps to prevent overheating or freezing, ensuring optimal performance and safety in any climate.

<u>Known Failures</u>
The 350squared system crossed safety operational threshold of 90% SOC, caused by a control bug in the AC-DC operation of the system- as Stargazer lost internet connectivity to cloud optimizer. We have built redundancy with a the local edge controller for failures of cloud optimization. Similar failure, the 350squared system rapidly discharged to a low of 6.4% percent. This was due to a network failure where Stargazer lost communication with the system for a few days. For a few hours, the AC-DC control kept acting on the previous Stargazer discharge action. A manual network restart restored our communication with the system. Upon receiving the latest SOC of 6%, Stargazer immediately recognized the critical levels and began charging to 30% SOC once it was safe to do so.

Finally, the battery BMS were reporting a default SOC of 42% to our software. This SOC was incorrect and due to a misreading from the CAN bus. Stargazer kept receiving a value of 42% SOC and made recommendations based on that value, thus resulting in incorrect recommendations. We solve default SOC value issue would be solved by cycling batteries periodically.

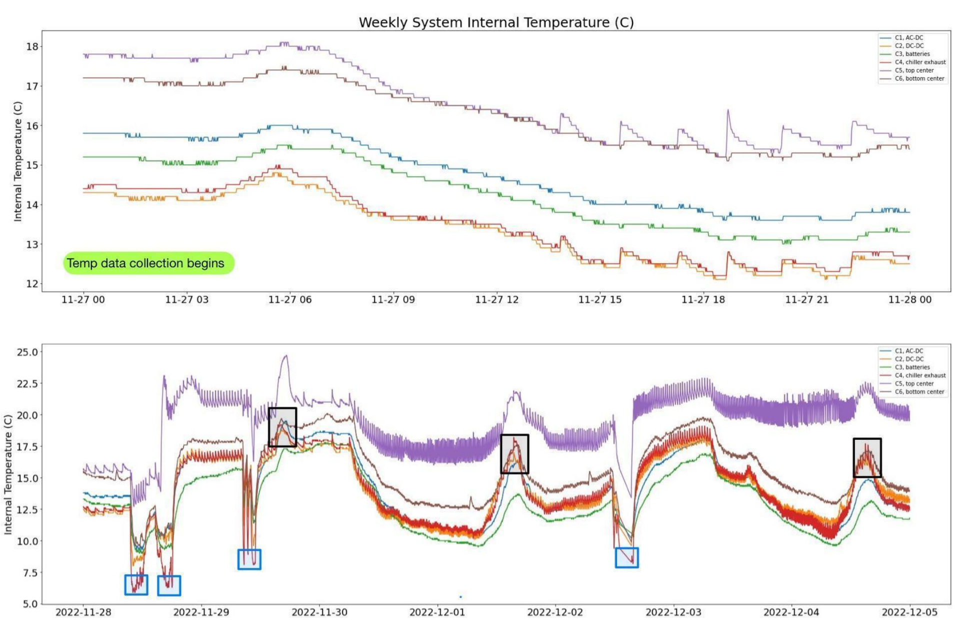

Figure 6: Internal and site temperature profile

7.2 Building load and on-site renewable energy generation support

During times of low-to-no solar generation hours, Stargazer helps support IBEW's site load by feeding energy back into the grid. To date, the system has fed 68 kWh electricity. This allows for various benefits to both the local grid and the site.

Reliability and Continuity of Power Supply: During times when there is no solar generation, the ability of ElectricFish's system to support the load by feeding energy back into the grid ensures that there is no interruption in the power supply. This is particularly important for IBEW, a facility that requires a continuous power supply for their operations. Without this capability, these facilities would need to rely on other, possibly less environmentally friendly, power sources during periods of no solar generation.

Reduction of Grid Stress: By feeding energy back into the grid during periods of no solar generation, the ElectricFish system helps to reduce the overall stress on the grid. When solar energy is unavailable, other sources have to make up for the shortfall, which can put additional stress on these sources and on the grid as a whole. By supplying energy during these times, ElectricFish helps to alleviate this stress.

Improved Grid Stability: The ElectricFish system can help balance supply and demand and prevent issues like blackouts that can occur when the demand for electricity exceeds the supply.

Cost Savings and Efficiency: From an economic perspective, being able to use stored energy during periods of no solar generation can lead to cost savings. This is especially true in areas where electricity prices are higher during peak demand periods, which often coincide with times when solar energy is not available.

Environmental Impact: By using renewable energy stored during periods of excess production, Stargazer helps reduce reliance on non-renewable energy sources that are often used as backups when solar power isn't available. This helps reduce the overall carbon footprint of the energy system.

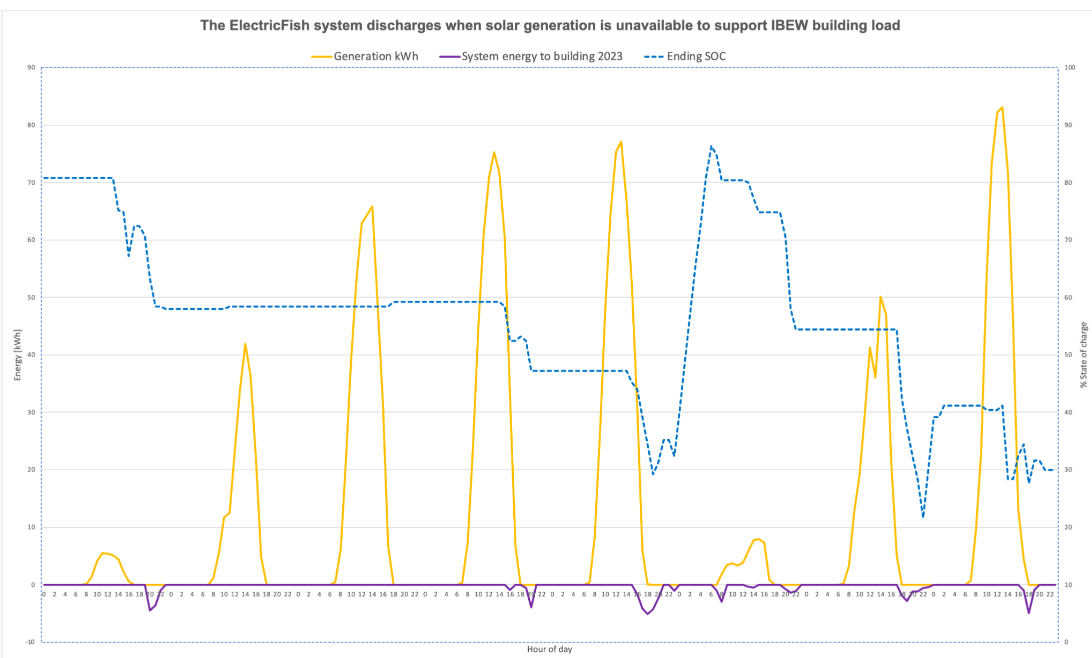

Figure 7: Supporting building load during off-peak solar hours

7.3 Mitigating Grid Strain during DCFC sessions

As part of our comprehensive review of ElectricFish's charger deployment at IBEW 58, we conducted a focused examination of a seven-day period with multiple DC Fast Charging sessions. This focus allowed us to study how our system manages peak energy demand periods. We compared two scenarios to assess the impact of our EF system on the energy consumption during DCFC sessions.

Our analysis, as visualized in Figure 7, revealed notable differences between the two scenarios during the DCFC sessions. In the hypothetical scenario without the EF system (most notably on Tuesday, 04-04-2023), energy consumption sharply spiked during these sessions, suggesting a significant and sudden strain on the grid due to the high power requirements of fast charging. However, with the EF system in place, these peaks were significantly curbed. This demonstrates that our system effectively managed the high energy demand during these grid strain events.

The legends describe theoretical scenarios: one without the ElectricFish's interconnection, and the other with the presence of the ElectricFish's microgrid system. The former considers the site load, onsite solar generation, and the energy usage of the EF system. The latter considers the IBEW site load, onsite solar generation, and the energy load of the EF DCFC sessions.

The plots on the right, averaged over a 15-minute period, represent the ability of ElectricFish charging to reduce the peak charging load and to smooth overall energy consumption profiles. Battery-buffered EV charging is a promising solution that addresses many challenges of charging electric vehicles, such as grid stability, peak demand, and charging time. By incorporating battery storage into charging infrastructure, demand spikes can be smoothed out, grid congestion can be reduced, and faster charging can be enabled without overloading the grid.

ElectricFish's battery-buffered charging stations can provide a reliable backup power source in the event of a grid outage or emergency. As the demand for EVs grows, battery-buffered charging is likely to become increasingly important for both public and private charging infrastructure.

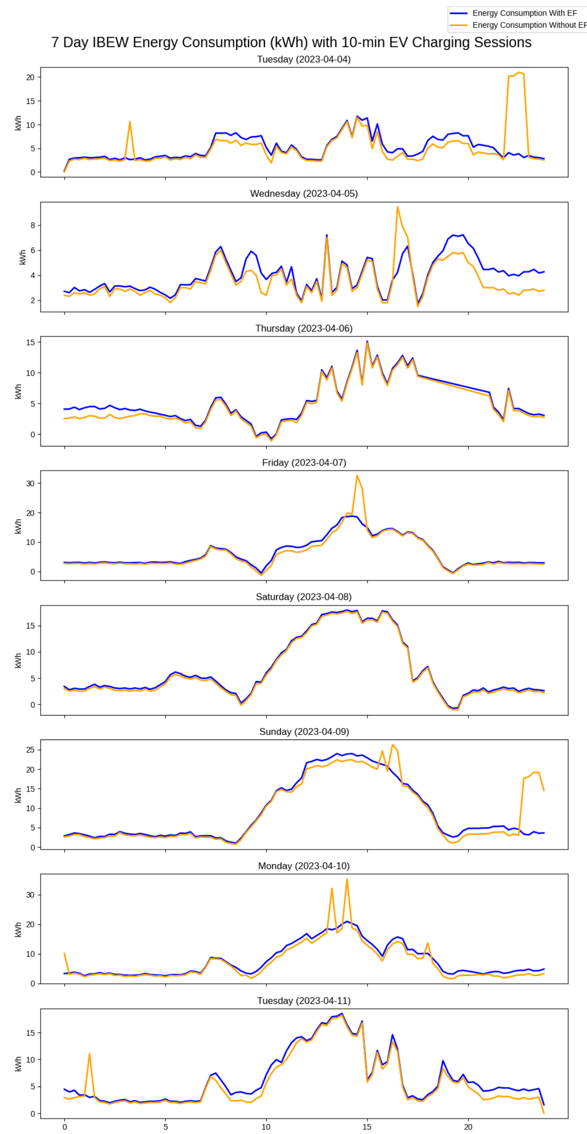

Figure 8: Analyzing Energy Consumption during 10-minute DCFC sessions, during different days of the week.

8. Software Network Components and Performance

ElectricFish's optimization engine, Stargazer, demonstrated a robust performance with an uptime of 99.6%, indicating consistency and stability. Even under continuous usage, Stargazer is able to operate and deliver real-time predictions with more than 44,000 total executions to date with an average execution time of 8 seconds. Stargazer's efficient use of computing power yields an exceptionally low cloud footprint. This efficiency results in a twofold benefit: it optimizes resource usage, leading to cost savings, and it minimizes environmental impact, aligning with our commitment to sustainability.

Moreover, ElectricFish has multiple digital dashboard and monitoring systems, for the ease of customers to manage and monitor their assets.

8.1 ElectricFish Charging Management System (ECMS)

During the six month pilot, the ElectricFish Charging Management System (ECMS) proved its reliability, achieving 80 successful charging sessions. It generated $410.67 via RFID-initiated transactions and added $57.75 through credit card payments. The ECMS dispensed a total of 659.48 kWh of energy, underlining its efficiency.

8.2 Real-time Energy Efficiency Framework (REEF)

REEF serves as a comprehensive, customer-facing data visualization platform, making it a critical interface between ElectricFish's services and users. Along with geolocation capabilities and safety alarm notifications, REEF allows the customer to have real-time monitoring of charging operations and understand their energy consumption patterns and behaviors. REEF also displays real-time grid sources and the volume of renewables ingested by the unit. This transparency not only keeps customers informed about their energy usage but also highlights our commitment to sustainable energy practices. With a server uptime of 99.95%, customers can rely on REEF for virtually uninterrupted access to their energy data. Even during necessary system maintenance and updates, REEF ensures minimal disruptions, reinforcing its role as a reliable, customer-centric platform.

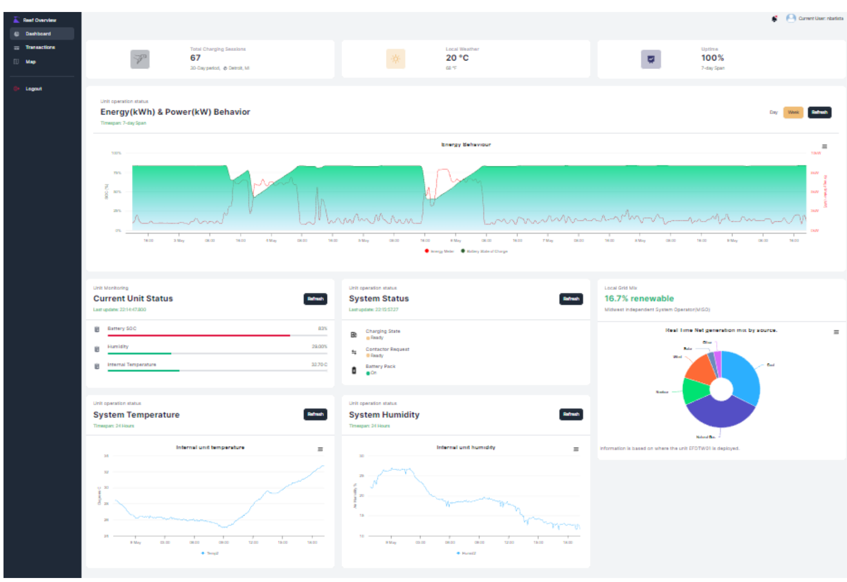

***Figure 9*: ElectricFish's Reef dashboard**

9. Conclusion

ElectricFish built and deployed a pilot unit of their microgrid-integrated EV charging station, which took a total of 23 weeks to build and deploy. The cost for permitting, installing, and insuring the system was $10,526, demonstrating a 90% reduction in installation costs for EV-DCFC systems with their system architecture. Shipping accounted for 43% of the $30,000 deployment cost, which also included maintenance over the 6-month demonstration period. The optimization engine, Stargazer, demonstrated a robust performance with an uptime of 99.6% and efficient use of computing power, resulting in cost savings and minimized environmental impact. The system served 9600 miles of charging, saved 25 times in installment costs compared to other chargers, and had 100 times faster deployments.

The novel hardware, supported by Stargazer's DER load-balancing algorithm, helps alleviate sudden grid strain during DCFC sessions, contributing to the overall health of local grid infrastructure and promoting greater grid independence and resilience. This enhances energy management, scalability of EV adoption, and sustainability efforts, particularly by optimizing the use of renewable energy sources during periods of high demand.

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