Stephanie A. Cuello
SENIOR COUNSEL

April 28, 2025

VIA ELECTRONIC FILING

Adam J. Teitzman, Commission Clerk
Florida Public Service Commission
2540 Shumard Oak Boulevard
Tallahassee, Florida 32399-0850

Re: *Duke Energy Florida, LLC's Demand Side Management Annual Report for Calendar Year 2024*; Undocketed

Dear Mr. Teitzman:

Please find enclosed for electronic filing Duke Energy Florida, LLC's Response to Staff's First Data Request (Nos. 1-12).

Thank you for your assistance in this matter and if you have any questions, please feel free to contact me at (850) 521-1425.

Sincerely,

/s/ Stephanie A. Cuello

Stephanie A. Cuello

SAC/clg
Enclosure

Cc: Michael Barrett, Division of Economics, mbarrett@psc.state.fl.us; discovery-gcl@psc.state.fl.us

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DUKE ENERGY FLORIDA, LLC'S (DEF)
RESPONSE TO STAFF'S FIRST DATA REQUEST (1-12)
REGARDING THE 2024 DSM ANNUAL REPORT

1. Please describe how Duke Energy Florida (DEF or Company) monitors current federal energy efficiency standards and Florida Building Code requirements. If applicable, discuss any changes implemented in 2024, compared to the methods used in 2023.

Response:
DEF's approach to monitoring any new federal energy efficiency standards and Florida Building Code requirements involve both internal and external resources. DEF stays informed about new federal energy efficiency standards and Florida Building Code requirements through participation in trade associations, industry groups, and building associations. DEF also stays informed about new technologies through monitoring activity in the other Duke jurisdictions, market potential studies, meetings with peer utilities and review of regulatory filings.

DEF has not changed the method or the way it monitors current federal energy efficiency standards and Florida Building Code requirements.

2. What impact, if any, did changes in federal or state standards that occurred in 2024 have on the cost effectiveness of DEF's conservation programs?

Response:
There is no impact due to changes in the federal or state standards on the cost effectiveness of DEF's conservation programs in 2024.

3. What changes in federal, or state standards have occurred in 2025, or are projected to occur before the end of 2025, will (or could) impact the cost effectiveness of DEF's conservation programs? Please explain.

Response:
There are no anticipated changes in the federal or state standards that are anticipated to occur in 2025. Projected changes that could impact the cost effectiveness of DEF's programs would be funding challenges with state or federal agencies.

4. In 2024, what was the Company's System Average Line Loss percentage?

Response:
Residential - 5.55%
Non-Residential – 4.72%

5. The Summary page of the Report refers to the utility's Technology Development program, and also to the Vehicle to Grid Ford Lightning EV study within that program.

A. Identify and describe any new conservation research and development (CRD) initiatives that were launched within the Technology Development program in 2024.

Response:
Although there were no new conservation research and development initiatives launched in 2024, the preliminary investigations of several technologies from prior periods, resulted in several new projects that will launch in 2025.

Additionally, several research and development projects continued in 2024, below are a list of the projects:

- Continued a project to evaluate the energy efficiency and demand response capability of an energy storing, ultra-efficient, commercial packaged air conditioner technology that combines dew-point-style sensible cooling with liquid desiccant dehumidification. This technology implements indirect evaporative cooling using a liquid desiccant. This desiccant can be recharged and stored in a tank for use later. This stored energy can be used to make the peak power consumption very low. DEF is piloting this technology configured as Dedicated Outdoor Air Systems (DOAS) at two volunteer customer sites. The energy consumption of this technology will be documented at both sites. If the testing is successful, this technology could be included in future EE and DR programs.
- Continued a project with the University of Central Florida (UCF) to document the value of long-duration customer-side energy storage systems. This project is using the technology at UCF's Microgrid Control lab to directly test a long-duration energy storage system. Use cases to be investigated include study of battery performance during charging and discharging, documenting the effects of cycling on battery performance (battery degradation, efficiency, etc.), optimal operation of a battery energy storage system in a distribution system with high penetration of solar energy, control of behind-the-meter distributed energy resources to provide services including, peak capacity management, demand response (consuming or generating), frequency regulation, ramping capability and voltage management.
- Continued a project with the University of South Florida (USF) to leverage customer-sited solar PV and energy storage at the USF 5th Avenue Garage Microgrid. The system provides load smoothing, islanding, and demand response. A publicly available dashboard that shows live data, project specific facts and the capability of downloading data for further study is available for the site at https://dashboards.epri.com/duke-usfsp-parking. The result of this research may be used for the design of a potentially cost-effective DR program. USF continues its research on microgrid operation.

- Continued the Electric Power Research Institute (EPRI) Solar DPV project for data collection to document customer solar resources with a focus on larger PV arrays with and without energy storage. This project also provides the data stream for the dashboard mentioned above.
- Partnered with EPRI and other research organizations to evaluate EE, energy storage, and alternative energy/innovative technologies.

B. Provide updates on the Vehicle to Grid Ford Lighting EV study and all on-going CRD initiatives that began before 2024, and if applicable, attach interim and/or final reports on work completed in 2024.

Response:
DEF continued to evaluate the demand response capability of the Ford Lightning Electric Pickup Truck in a Vehicle-to-Grid (V2G) configuration in 2024. The pilot consists of lab testing of the vehicle, electric vehicle charger and home integration system. DEF continues to test the system in four employee-volunteer DEF customer homes. This project focuses on the capabilities of the Ford Lightning EV to provide V2G demand response, Vehicle-to-Home backup power and EV charging control. These systems could be a valuable future potential resource as a component of DEF's DR Portfolio.

DEF also completed a pilot to develop software, firmware, and applications for a Smart Home Gateway to evaluate the potential for a future home energy management program and its ability to enhance the Company's future energy efficiency and DR programs. The Smart Home Gateway currently includes processing and communications capabilities to perform on-site operations including receiving energy data from the customer's AMI meter, communications using four radios and on-site processing. Capabilities were developed and tested that included enabling appliance demand response using CTA-2045 (EcoPort) local control and enabling local control of Energy Management Circuit Breakers (EMCBs) for monitoring and demand response. These technologies allow automatic control of devices according to the customer's preference, and enabling open-source, utility-demand response using OpenADR. The Smart Home Gateway can also be used to engage customer awareness of how energy is being used in the home. These capabilities will be considered in the development of future EE and DR programs. The final report is attached hereto as Exhibit A.

6. On page 3 of the Report, DEF provides information on the Home Energy Check program. In 2024, DEF conducted a total of 29,423 residential audits; however, in 2023, DEF conducted a total of 36,915 residential audits. Please explain the reason(s) for the 20% decline in the number of audits conducted from 2023 to 2024.

Response:
The higher number of audits in the Home Energy Check (HEC) program in 2023 compared to 2024 was driven by increased customer demand following prolonged elevated temperatures in the summer of 2023. Residential customers sought advice to improve their overall energy efficiency and recommendations for energy-saving home improvements. This resulted in increased program participation for residential audits and was the major factor that accounted for the variance between 2023 and 2024.

7. On page 5 of the Report, DEF provides information on the Neighborhood Energy Saver program. The Total Program Cost of the Utility increased from $6,627,000 in 2023 to $7,949,000 in 2024. Please explain why the Total Program Cost increased in 2024 by about $1.3 million while the number of participants decreased, compared to the prior reporting period (2023).

Response:
The increase in program cost in 2024 is attributed to the higher number of insulation measures associated with the program which shows the higher number of participants and total square footage involved. Although we had fewer "whole house" participants in 2024, a greater number took part in insulation measures compared to 2023.

8. On page 6 of the Report, DEF provides information about the Low-Income Weatherization Assistance program. Column f shows that participation rose in 2024 (317), compared to the results from 2023 (184).

A. What factors does DEF believe contributed the most to achieve increased enrollment in 2024? Specify in your response whether those efforts are still in place for 2025.

Response:
DEF believes that Agency Funding contributed the most to LIWAP's program participation. DEF actively encourages agency participation in the program. DEF is also committed to providing energy education not only to participating agencies but also to DEF customers at community events and activities.

B. Describe what actions the Company undertook in 2024 to provide its customers with information describing how to enroll in this program. Address in your response if any new participating agency relationships were established in 2024.

Response:
In partnership with the Duke Foundation and the Florida Housing Coalition DEF participated in a five-part webinar series with State Housing Assistance Program administrators across the Company's service territory in Florida. DEF shared information about this program and from that series DEF had done agency that signed up and is fully participating and two other agencies that DEF is currently working on agreements with.

C. Please provide the number of enrollments processed through each participating agency which added to the 317 total participants in 2024.

Response:
Central Florida Community Action Agency- 26
Centro Campesino -14
Marion County Community Services-2
Meals on Wheels- 22
Mid Florida Community Services- 124
Orange County- 4
Osceola Council on Aging-46
Pinellas County Urban League-79

D. Please explain why the per installation savings values for this program (the kilowatt values for summer and winter demand reduction and the kilowatt-hour value for annual energy savings "@ meter" and "@ generator") all increased for 2024, when compared to the values for 2023.

Response:
The increase is due to program participation increasing from 2023 to 2024. Also, the difference between the @meter and @generator during the reporting period is factoring in the line loss percentage.

E. Please show how the Net Benefits were calculated for this program. In your response, please provide an Excel spreadsheet with the formulas intact.

Response:
Please see attached excel document labeled Exhibit B for details on how the Net Benefits were calculated for this program.

9. Page 7 in the Report reflects that participation in the Residential Load Management program fell from 2,916 in 2023 to 2,579 in 2024. Specifically describe the marketing and outreach methods and techniques that were used to promote this program. Address in your response why program enrollments declined in 2024 compared to 2023.

Response:
In 2024, the Residential Load Management program adjusted marketing and outreach efforts to specifically achieve the annual goal of 2,500 new participants. These "goal oriented" marketing efforts included email, newsletters, bill inserts and website promotions. The enrollments did exceed the annual goal, but did decline year over year due to the more targeted marketing campaign designed to achieve but not exceed this annual goal.

10. Page 8 in the Report reflects that participation in the Business Energy Check program fell from 479 in 2023 to 325 in 2024. Please explain why program enrollments declined in 2024 compared to 2023.

Response:
The Business Energy Check program markets the audit to the DEF customer base through a few different channels, such as emails, direct mail, bill messages and bill inserts at trade shows as well as by word of mouth. This program has three different opportunities for a customer to receive an audit; the onsite audit, the phone assisted audit and the online audit. This program also fulfills all customer requests for audits as the customers approach DEF through various marketing channels. Customer audit requests were lower in 2024 compared to 2023 and this in turn reflected decreased participation in 2024.

11. Please refer to Page 9 of the Report (Smart $aver Business program). In 2023, DEF reported the Net Benefits of Measures Installed During Reporting Period as a negative $917,000. In 2024, however, DEF reported the Net Benefits as a positive $808,000. Please explain the reasons for this large change in Net Benefits.

Response:
There was an error in the net benefits for this program in 2023, resulting in an understatement of the net benefits. The correct Net Benefits for 2023 were $2,178,348.

12. Please refer to Page 11 of the Report (Commercial Energy Management program), which is a program that is closed to new participants. The utility states that its cost per installation increased from $10,397 in 2023 to $11,025 in 2024. Given that this program is closed to new participants, please explain the nature of these installation costs and why they have increased in 2024 compared to 2023.

<u>Response</u>:
Although the program is closed to new participants, older control devices were identified for replacement in 2024, causing the cost per installation to increase on those devices.

Home Energy Management System

Pilot Structure and Results

May 2024

The Home Energy Management System (HEMS) report covers the Duke Energy pilot goals and objectives. This report includes the HEMS configuration, hardware used and test results from the pilot. This report includes the potential next steps of the HEMS.

Home Energy Manager System Pilot Objectives

This project will develop software, firmware, and applications for a Smart Home Gateway that will enable demand response. The Smart Home Gateway currently includes processing and communications capabilities to perform on-site operations including receiving energy data from our AMI meter. We will develop local control integration with CTA-2045 appliances and the Eaton Energy Management Circuit Breaker (EMCB) to test water heater, pool pump, EVSE, and thermostat demand response. We will develop bindings to control common IoT devices, such as commonly available thermostats, lighting, etc. Demand response capabilities will be developed using the CTA-2045 and OpenADR protocols. DEF will document this project for a potential Energy Efficiency and Demand Response Program.

The Home Energy Manager System (HEMs) pilot proof of conception was to demonstrate the management of multiple technologies and protocols with a central system to control the end devices reporting to the system along with the input of smart meter data. This system was to be configurable for the devices present in the pilot home, while respecting the pilot participant system configurations.

System Design

The Smart Home Gateway, an x86 based single board computer was previously developed for the smart meter usage app (SMUA) program and because the device already had the ability to read the meter locally it was a good candidate for a Home Energy Management System.

The HEMS application was put into a containerized package that allows for independent secure distribution to only targets Smart Home Gateways.

Node-RED was selected as the backbone for integration of the HEMS devices and protocols. Node-RED was originally developed by IBM's Emerging Technology Services on top of Node.js and allows for rapid development of many different protocols.

The model of the HEMS was built so that it would allow for easy addition of new devices or protocols. The goal was to keep as many integrations local as possible and to allow the flexibility to configure each HEMS specific to the pilot site for what devices were available.

Pilot Participants

Participating in the pilot are three sites with HEMS and smart devices. Site 1 and site 2 are residential homes and site 3 is a test lab environment. Equipment is present from previous pilots and additional smart device equipment was added for this pilot.

Site 1

- CTA-2045 A.O. Smith Vortex Heat Pump Water Heater
- CTA-2045 Emerson Thermostat
- Ecobee 3 lite thermostat
- 3 – Shelly Smart Plug Switches

- Eaton Green Motion Direct Panel EV Smart Breaker
- Eaton Green Motion Wall Charger EV Smart Breaker

Site 2

- CTA-2045 Emerson Thermostat
- Ecobee 3 lite thermostat
- Midea Slim Duct Variable Capacity HVAC
- 2 - Shelly Smart Plug Switches
- 2 - Eaton EMCB Desktop with Outlet
- Sonoff Plug

Site 3

- 9 – Eaton EMCB Panel Located Breakers
- A.O. Smith SHPT Heat Pump Water Heater
- A.O. Smith Resistive Water Heater
- Pentair Variable Pool Pump
- CTA-2045 Emerson Thermostat
- Ecobee 3 lite thermostat
- 2 - Shelly Smart Plug Switches
- CTA-2045 Mitsubishi Mini-Split
- Eaton Green Motion Direct Panel EV Smart Breaker
- Eaton Green Motion Wall Charger EV Smart Breaker
- Emerson Water Heater Load Switch

System Design and Capabilities

The protocols/standards used by the system are as follows:

- MQTT – Messaging Protocol
- OpenADR 2.0b – Open Automated Demand Response
- RPC (Remote Procedure Call) over Http – Used for communication to Shelly Devices
- Zigbee – Wireless communication between meter and HEMS
- HTTP REST API – Used to communicate to Eaton Cloud for Smart Breakers
- UDP – Used for communicating locally to Eaton Smart Breakers
- CTA-2045 – Communication between the UCM (Universal Communication Module) and SGD (Smart Grid Device)

Node-RED Flows

Node-RED utilizes flow-based programming, where functions are in a black-box like structure (node) and the result is then passed to the next node. The programming takes place in a web user interface.

Node – The building block of a flow, these elements receive and send messages passed along a wire. The transformation or utilization of the message takes place in this element. These can also be triggered by external hardware (input pins) or external events such as an incoming HTTP request.

Wire – Connects each node together. They represent the direction of the message.

Palette – The area that displays the list of nodes installed.

Palette Manager – Allows for the search and installation of nodes. (Under Main Menu)

Workspace – Where the nodes are placed to be wired together.

Flow – The tab representing a workspace to help organize nodes. It can also represent a group of nodes connected together.

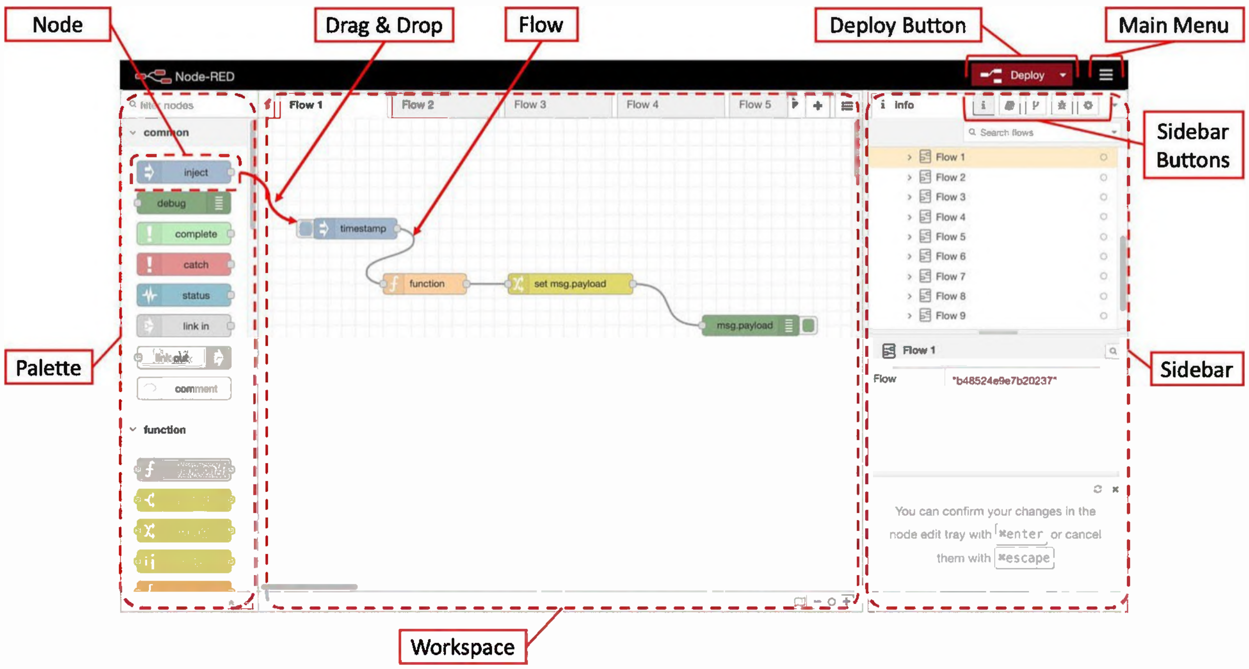
Deploy Button – Compiles the flow, then runs the code from the flow on the host machine.

Main Menu – Provides a link to several different options.

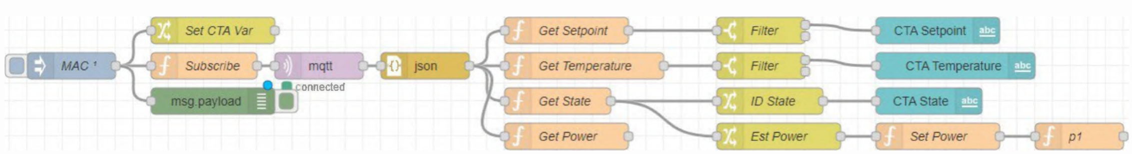
Sidebar – Selection of the displayed information on the right side of the screen. Often used for debugging, seeing more information on a node, the help information of a node, or the configuration of the nodes.

Sidebar Buttons – Allows for the selection of configuration, help, debug, information and dashboard configuration.

Example



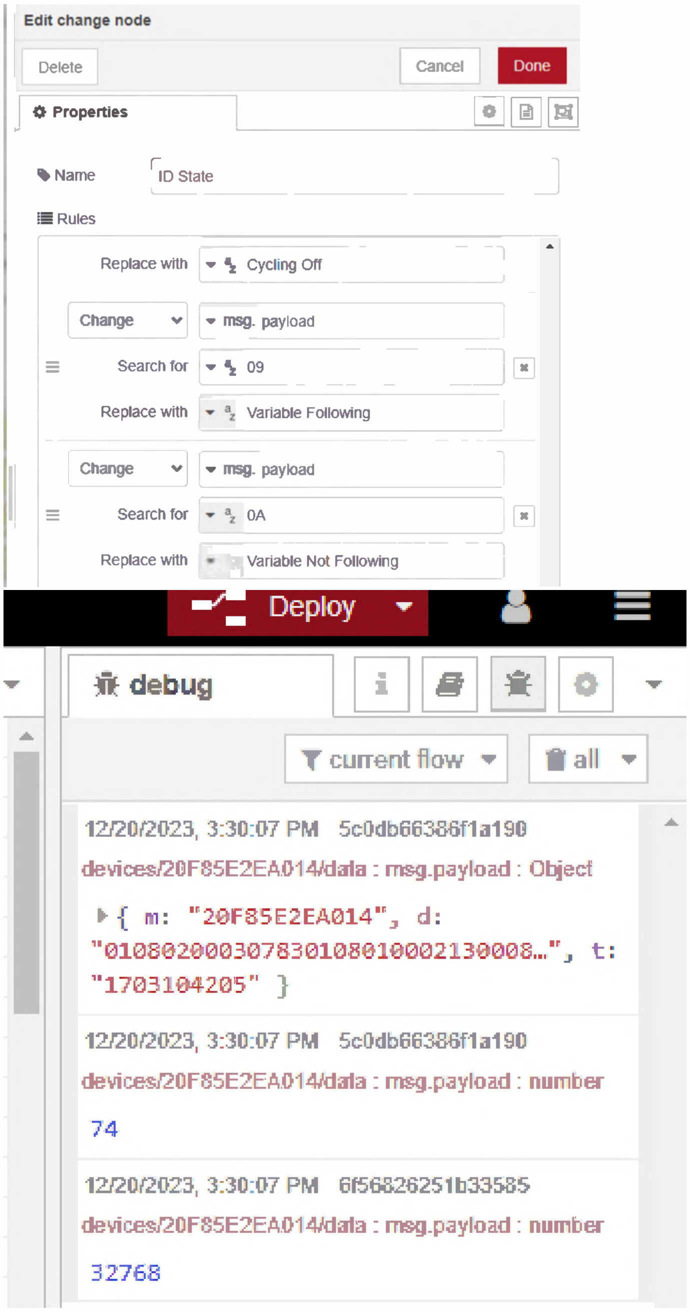
Example Flow –CTA-2045 Module



This flow shows the MQTT connection, the receiving and decoding of messages to the CTA-2045 Skycentrics module. This is only a portion of the entire CTA-2045 module flow. The command-and-control portion of the flow was omitted.

The "MAC" labeled node is an Injection node, it has been configured to output the MAC address of the CTA-2045 module that is paired with the HEMS. This MAC message flows into the "Set CTA Var", which has been configured to hold the MAC address in a variable for the next time the system reboots. The "Subscribe" labeled node is a Function node that runs a block of JavaScript within the function and is triggered when a message appears on the input. In this "Subscribe" function, a message structure is assembled to be passed to the "mqtt" labeled MQTT node. The MQTT node subscribes to MQTT topic that the CTA-2045 module communicates on. The output of the MQTT node is the messages that come from that module. The next "json" labeled node converts the string output of the MQTT node to a JSON format, for easier programmatic interaction. All of the following Function nodes do as they describe; "Get Setpoint", "Get Temperature", "Get State", and "Get Power" from the JSON message. The "filter" labeled node is a Switch node that only allows valid and expected numerical messages to pass through. The "filter" node for both the "Get Setpoint" and "Get Temperature" values, then pass it to the "CTA Setpoint" and "CTA Temperature" UI_Text node. This UI_Text node allows the information to be displayed on the HEMS dashboard. The "ID State" labeled node is a Change node that converts the CTA-2045 hexadecimal message into readable text for the end user on the dashboard. The "Est Power" labeled Change node is used to convert the state of the device to an estimated power. Since this is a thermostat that is unable to know the power of the HVAC it is attached to, this estimation must be made. Many CTA-2045 devices do know the power level and this information would come from the "Get Power" function without the need for the "Est Power" node. The "Set Power" Function node is used for what value the system has been configured for, then the power message is passed to the "p1" Function node. The "p1" Function node sets the running power for this device in a system variable that is used for calculation of all running devices, as well as other energy management functions.

The debug node labeled "msg.payload", displays the value of the message payload on the sidebar for debugging purposes. This also allows the display of debug nodes from other flows, so if some message is sent in another flow, it would be able to be seen on the debug sidebar for analysis.



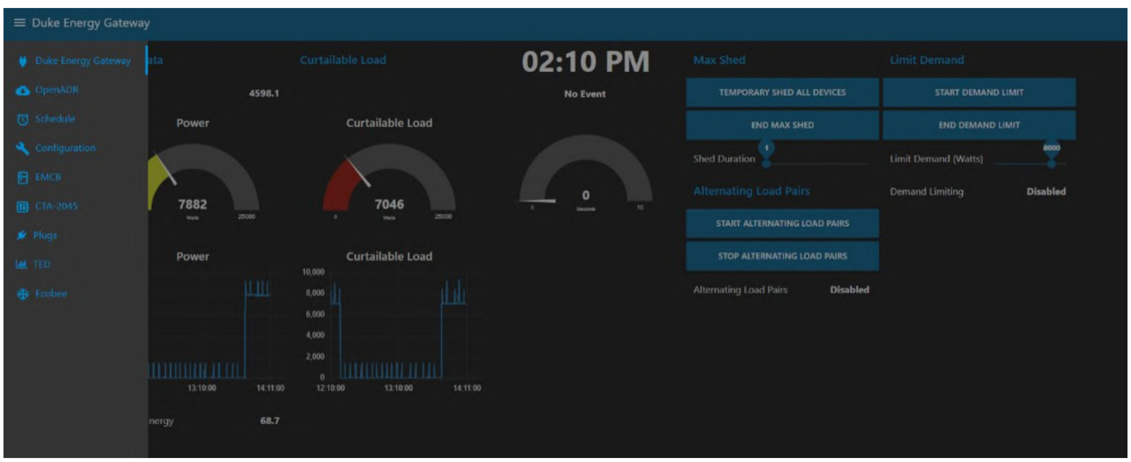
User Interface

The user interface (UI) is accessible on the local network by navigating to the IP address of the gateway, or if use pilot participant router supports mDNS (multicast Domain Name System) the hostname of the gateway can be used instead. This access can be done on most internet browsers, including those on tablets and mobile phones.

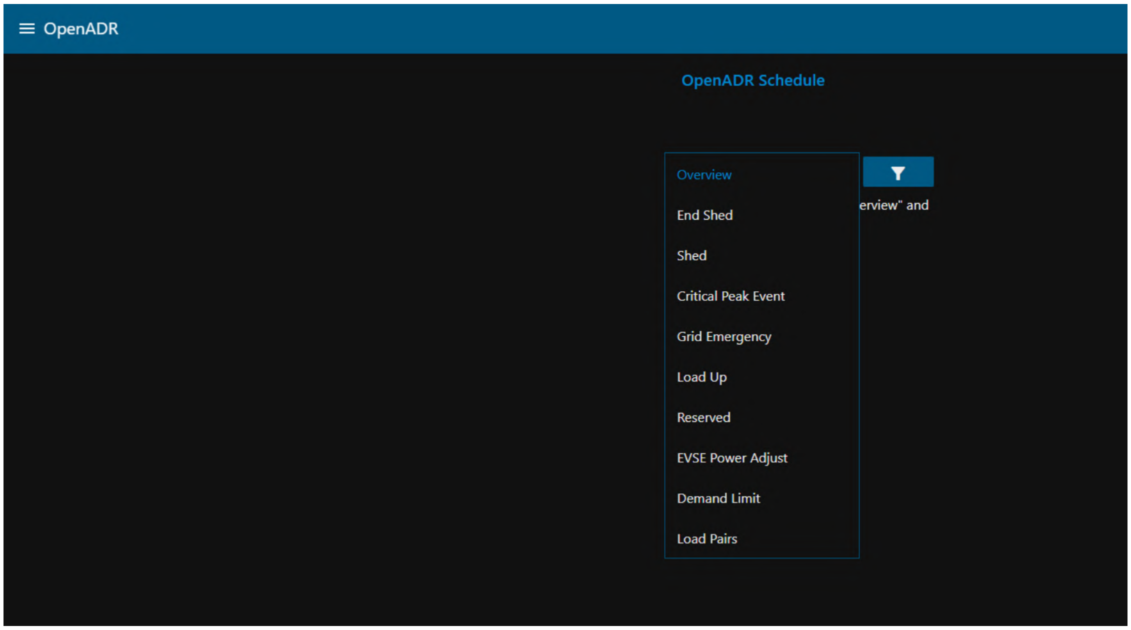
The main landing page for the HEMS has the following elements:

- Meter Data: The meter dial (total lifetime kWh) and instantaneous power (kW) information is displayed on a dial and a line chart.
- Curtailable Load: The curtailable load is the estimated cumulative total of the controllable loads available to be curtailed/controlled.
- Event Timer: The event timer displays the duration of time left in a control event in seconds.
- Max Shed: The Max Shed function will send an off command to all devices for a set duration in minutes.
- Limit Demand: The Limit Demand function will allow the initiation of demand limiting on the system as specified in watts.
- Alternating Load Pairs: The Alternating Load Pairs function will initiate the configured loads to alternate its state from the higher priority device. For example, when the higher priority device is in the "On" state, the lower priority device will be set to the "Off" state.

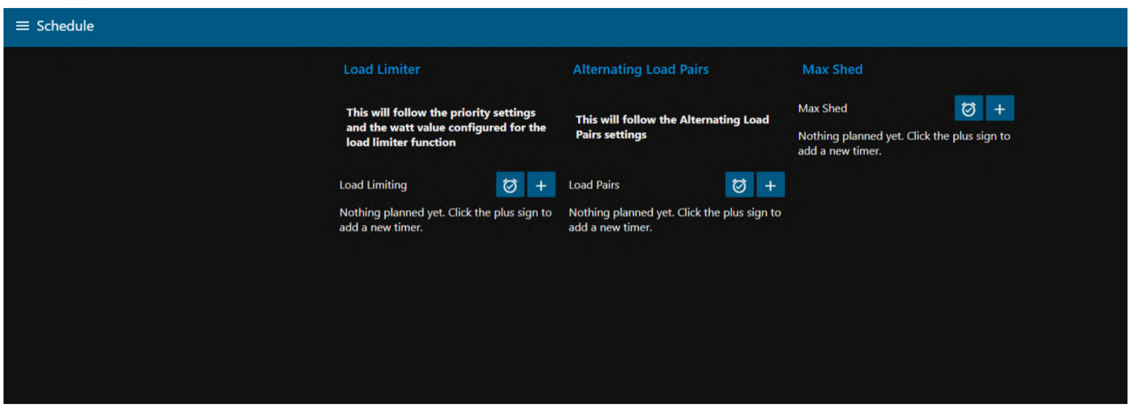
Navigation between HEMS pages is done by the hamburger menu in the upper left-hand corner. Only devices that have been configured for the specific pilot site will be available. For example, if a site does not have EMCB devices, that menu will not be available to the end user.



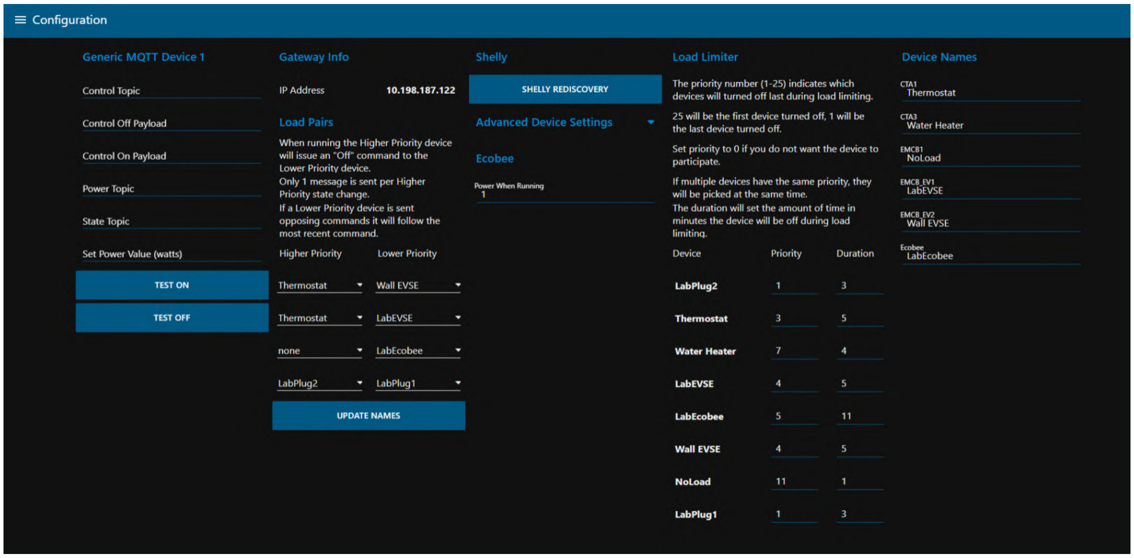
The OpenADR page displays all the OpenADR events scheduled by the utility, displaying the type of event and the duration of the event.



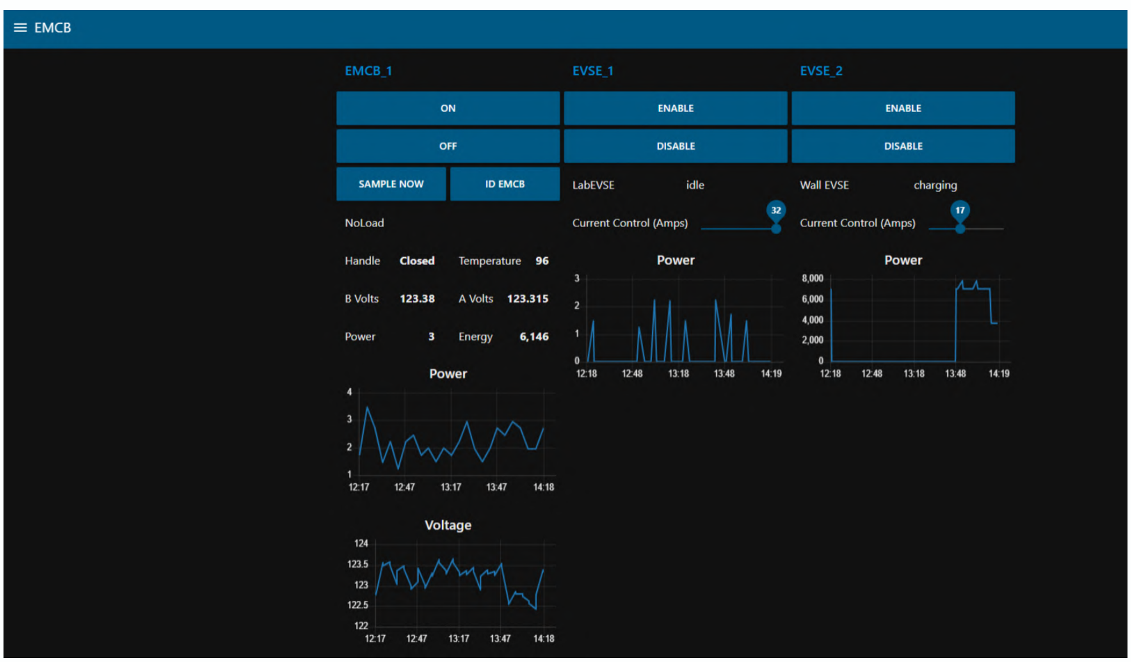
The Schedule page allows the HEMS participant to schedule the energy management functions.



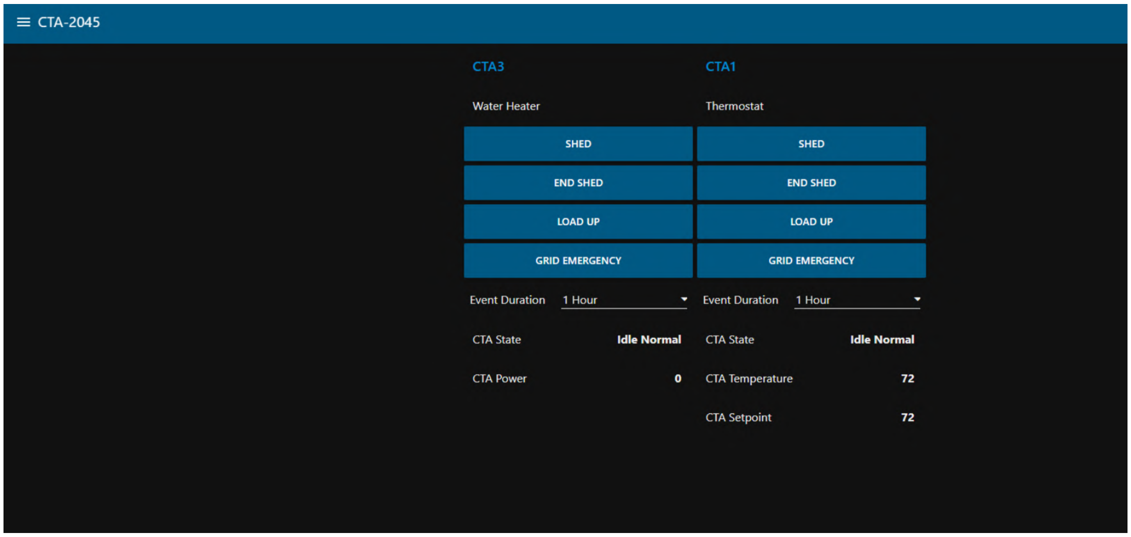
The Configuration page allows the participant to configure generic MQTT devices for HEMS participation. The configuration of the energy management functions is completed on this page as well. Advanced settings for the Ecobee, EMCB, CTA modules and the TED are also configured on this page.



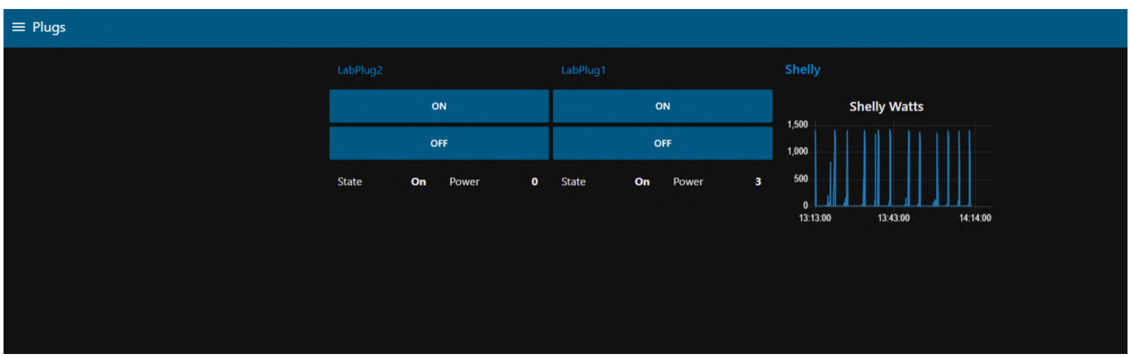
The EMCB page displays the Voltage, Power, Temperature and Energy of the standard EMCB. The standard EMCB has the ability to open or close the load. The EV_EMCB allows for the control of the Amps allowed through the charger as well as the ability to turn the charger on and off.



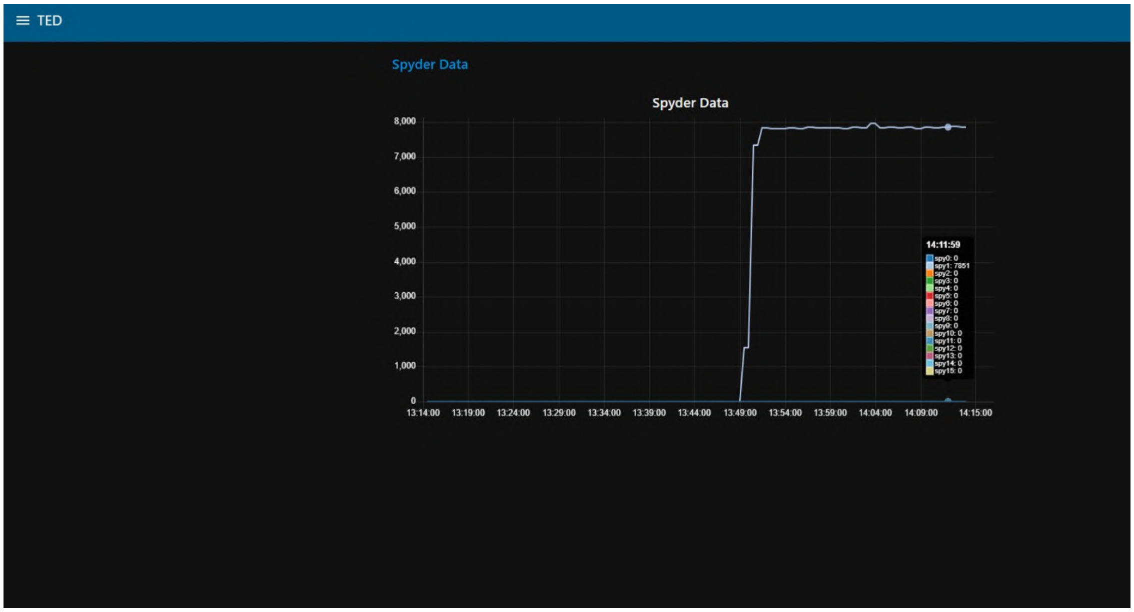
The CTA-2045 page displays the operating state of the end device, and also allows for the sending of commands to the end device. For devices that support temperature readings, this information is also return to this page.



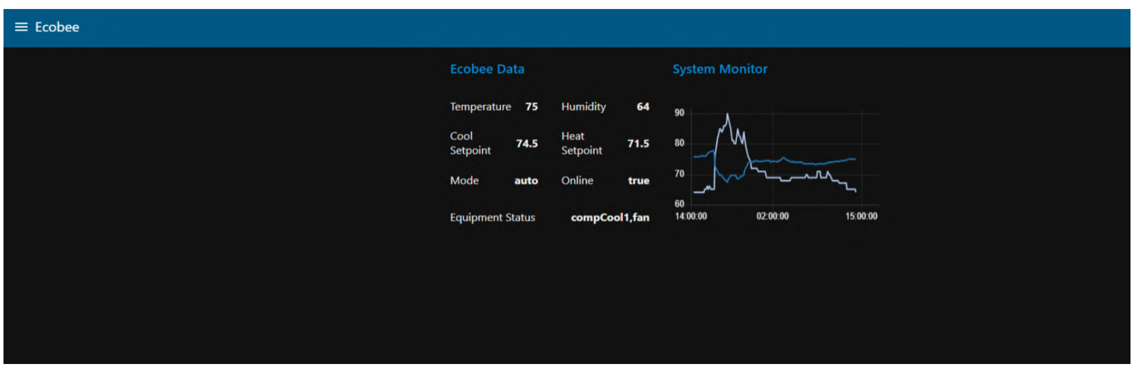
The Plugs page shows the state of each Shelly plug and the current power going through the device. All devices power readings are graphed to a single graph. Individual On/Off control can be initiated from this page as well.



The TED page pulls back all the readings from the TED and the Spyder channels for display to the end user.



The Ecobee page displays the Temperature, Humidity, Setpoints, Mode, Status and Online Connectivity. The Humidity and Temperature are graphed over time.



Energy Management Functions

The energy management functions are a set of user configurable rules to minimize demand and control multiple devices. These energy management functions can be run concurrently, but advanced consideration will need to be taken into account or some undesired behavior might take place.

The Max Shed command sends an "Off" signal to all devices that participate in the HEMS. Once the timer on the Max Shed has concluded an "On" signal will be sent back to the devices. This timer can be stopped at anytime by pressing the "END MAX SHED" button on the main page.

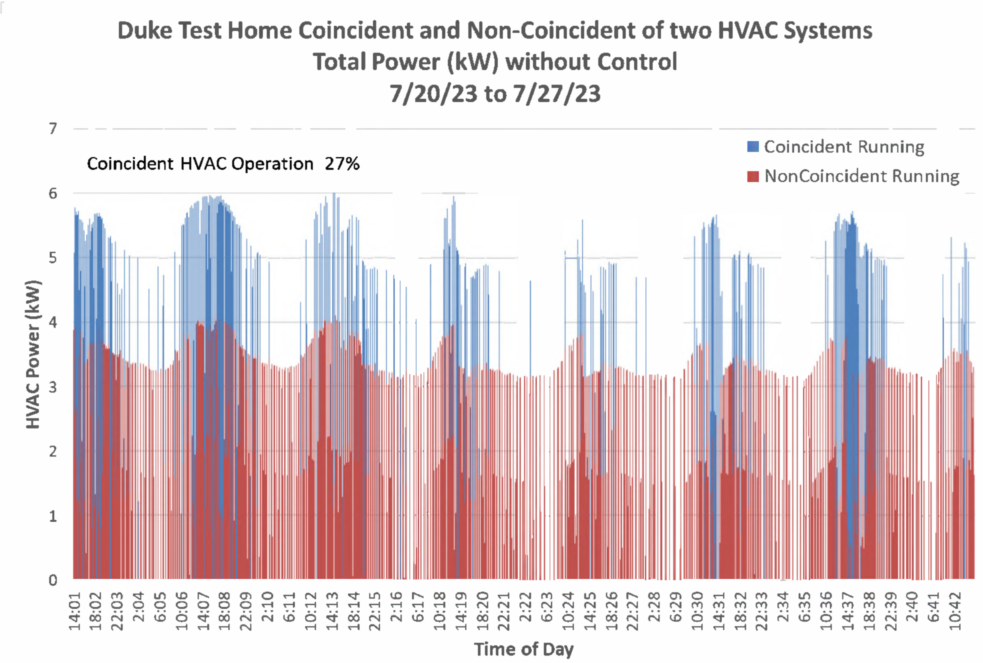
The Limit Demand function allows the user to set a maximum demand in watts for the participating devices not to exceed. In the case of the maximum demand threshold being crossed the HEMS will shed the devices in order according to the priority configuration and duration set by the user. The priority of the devices can be set 1 to 25, where 25 will be the first device shut off and then 1 would be the last device to be shut off in order to be below the demand threshold. The user also has the ability to set the device priority to 0, so that the device is never shut off during this routine. The user has the ability to set the duration of the device being turned off. For example, if a device has a duration of 10 and it is called to shut off during this event, it will only be off for 10 minutes. As long as the demand threshold is not being exceeded, new device with lower priority numbers will not be called.

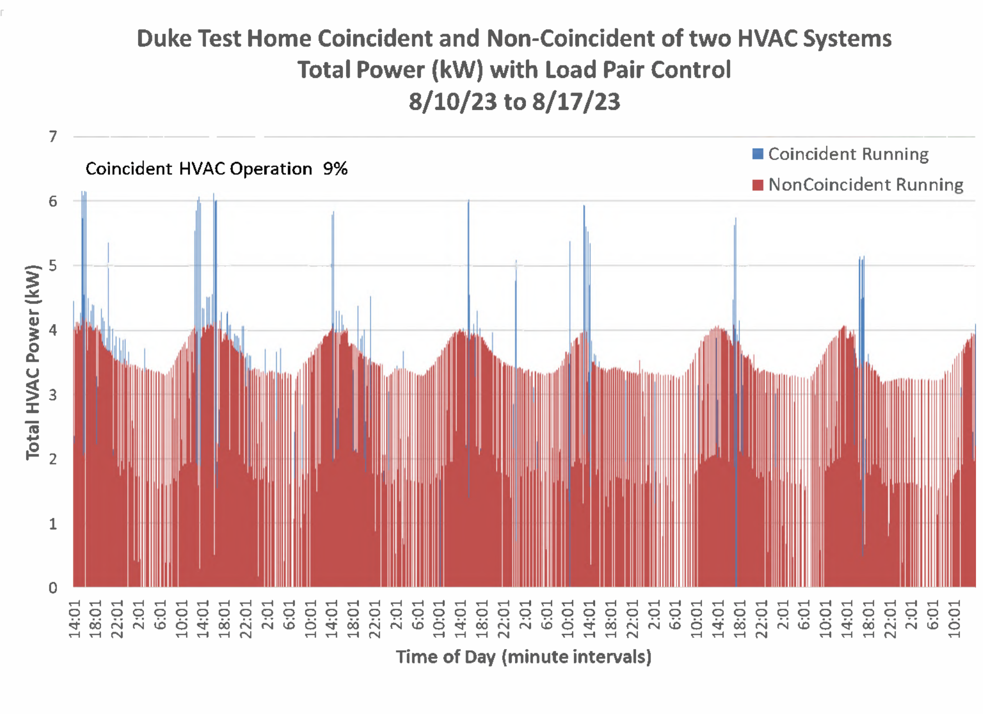
The Load Pairs function allows the user to pair a "Higher Priority" device with a "Lower Priority" device. When activated this function will send an "Off" message to the lower priority device whenever the higher priority device is actively using power. One single higher priority device can be used to trigger multiple lower priority devices.

Energy Management Demonstrations

Thermostat Load Pairs Demonstration

When using the Load Pairs function a pilot participant was able to pair an ecobee thermostat with an Emerson thermostat in their home. The Emerson thermostat controled an HVAC system in the second story of the home, while the Ecobee thermostat controled the first story HVAC. The Emerson thermostat was set as the Higher Priority device and the Ecobee thersmostat was set as the Lower Priority device. This setting would cause the first floor HVAC not to run while the second floor was cooling. In order to maintain comfort and safety, offsets were utilized rather than complete shutdown of the system. The limits that were put into place were: A 5 degree offset with a maximum temperature setting of 82 degrees. Even with the safeguards in place there was a 3 times reduction in coincident HVAC operation (27% to 9%). Without the safeguards this number would most likely have had a greater reduction in cincident opperations.





Demand Limiting Demonstration

-Insert Screenshots and explanation

Max Shed Demonstration
-Insert Screenshots and explanation

OpenADR
OpenADR 2.0B was utilized to initiate demand response events. The virtual top node (VTN) is a modified JAVA implementation. The HEMS acts as a virtual end node (VEN) to aggregate the messages and distribute them to the appropriate devices. The communication between the VTN and the VEN is secured by using certificates. All event messages are sent using the simple signal in a modified message structure.

Message Structure:

Simple Signal	Event Description	Notes
0	End DR Event	
1	Shed Max Load	
2	Critical Peak Event	Only applies to CTA-2045 Devices
3	Grid Emergency	Only applies to CTA-2045 Devices
4	Load Up	Only applies to CTA-2045 Devices
5-9	Future Use	
10-32	EVSE Power Adjustment	Only applies to EV EMCB. Limits the Amps to the set value
33-99	Future Use	
100-125	Activate Demand Limit	Signal Number -100 for the demand limit in kW
126-130	Future Use	
131	Activate Load Pairs	

Alternative Use Cases
Outside of the pilot participant control, the HEMS has been utilized in the Energywise Lab to gather power and energy data for both the Ford Vehicle to Grid (V2G) system, and the Moduly home battery system. The HEMS was also utilized to read MODBUS data from an inverter during testing.

Future Use Cases
Local EV EMCB
During development of the HEMS only cloud connectivity was available for the EV EMCB. As of December 2023, an initial release of locally connectivity to the EV EMCB was released. If developed further, this could lead to faster energy management response times and less dependence on internet connectivity.

Disaggregation
The HEMS would be able to support disaggregation of the meter data to provide more insights into the home energy use. This could also allow for devices that do not have smart capabilities to participate in the HEMS. For example if a home has a water heater without smart features, it

could be identified from its power signature as a virtual high priority device that could initiate the control of another device like a home thermostat or EV charger.

Open Charge Point Protocol (OCPP)

The HEMS would be able to support OCPP to manage electric vehicle chargers. This could be done locally and would allow many additional charger types to be added to the HEMS. This could also lead to the creation of a workplace energy managements system (WEMS), where multiple chargers could be managed at on location.

Thread/Matter

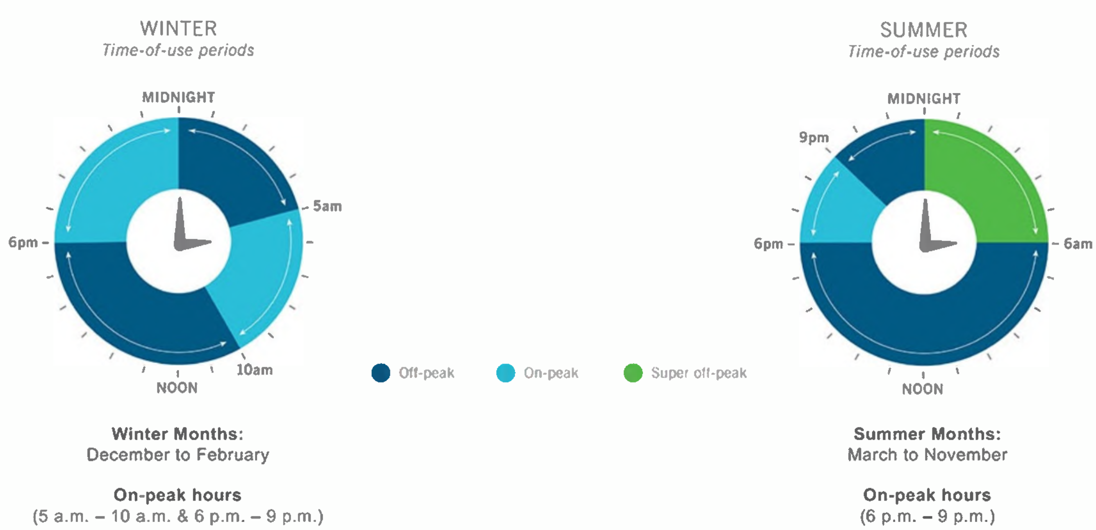
Many of the large players (Google, Amazon, Apple and IKEA) are in support of the matter protocol, so adding this capability to the HEMS would help open integration with many more devices coming to the market. The Thread hardware would either need to be added via a hub, USB dongle or included in a future revision of hardware.

Edge Artificial Intelligence (AI)

To assist in offline/edge AI analysis, the current onboard Mini PCIe slot could be utilized in combination with a Google Coral Tensor Processing Unit (TPU) for $25 (not at volume price). For better understanding of unexpected high bills this could open up the diagnostics of appliances (air conditioners), leaky home envelopes, and more advanced disaggregation. This could also aid in the configuration of appliances for demand response, requiring less input from the participant.

Time of Use (TOU) Scheduling

The HEMS could be further developed to allow user configurations for appliances to only run during specific times of day. This would be very cost advantageous to anyone participating in a TOU rate where it is more costly to run appliances during certain times of the day.



Real Time Pricing (RTP)

The HEMS could act as device manager for RTP participants and could be configured to only allow desired appliances to run if the rate is under a specific value. This could also be useful in displaying the rate whenever the participant wants to know the current price.

Instant Bill Total

The HEMS could support the participant to see their bill in real time, potentially increasing incentive to reduce use or identify what devices are contributing most to the bill. This could be a useful tool for those who have experienced an unexpected increase in energy usage.

Additional Energy Management Functions

In addition to the Load Pairs, Max Shed, and Max Demand, the HEMS could support additional energy management functions to allow participants more flexibility in how their appliances can participate.

Advanced Demand Response (DR) Programs

The HEMS could allow for pilot participation in advanced DR programs that are developed after the hardware is already deployed. An example DR program could be a price per kilowatt (kW) reduction, where the HEMS takes a snapshot of the current demand and allows a 3-minute window for the participant to reduce their demand (kW) for a set amount of time during the event. This could allow participation of additional devices for credit. For example, the participant could be notified during this event and could manually turn off the clothes dryer or unplug a standard EV charger.

Home Battery Integration

The HEMS could allow for a generic home battery management interface. The Energywise Lab has a Moduly home battery that could be a candidate once the APIs are developed for the battery. The HEMS could allow for rules to charge and discharge on demand, set minimum and maximum state of charge levels, and similar to the Load Pairs function, the battery could be setup to discharge during specific device operation and the battery could be setup to export when the home is over a specific set demand.

Solar

The HEMS could allow for coordination with solar production and device runtime. A Modbus connection has been temporary tested on the HEMS, but a full integration was never completed. Majority of solar inverters have a Modbus interface that could be integrated into the HEMS. The combination of a load adjustable EV charge like the EV EMCB could be coordinated with the production of solar to minimize export. The HEMS currently supports tracking of the exported energy and power data from the meter as well.

Modbus

Not only limited to solar Modbus can be used to integrate many other smart devices, like temperature sensors, relays and energy monitors. These additional inputs could be integrated into the existing energy management functions and could also aid in the development of new functions like those based off temperature.

Nest

Similar to the integration of the ecobee the HEMS could support other current thermostat manufacturers like the NEST thermostat from Google. This could open opportunities to homes that already have these devices installed.

Thermostat Controls

Currently the HEMS does not support user input for adjusting thermostat temperatures and running modes. These are features that could be added in future revisions of the HEMS. This may be useful for having rules based on temperature setting. For example, a participant may want the thermostat to set back a few cooling degrees when another appliance turns on that may generate addition heat.

CANBUS Data

Custom built device to pull CANBUS data from an electric vehicle, for more insight into the charge capabilities of the vehicle.

Custom CTA-2045 Module

The HEMS currently integrates with the Skycentrics CTA-2045 modules, however some of the shortcomings could be overcome by a custom CTA-2045 module. The custom module could allow for automatic integration with the HEMS and alternative communication methodologies (Zigbee/Thread/Bluetooth Low Energy).

HTTPS

The current implementation of the HEMS uses HTTP on the local network. To improve security, even though it is only locally accessible on the network, an implementation with HTTPS would be preferred. Currently all requests that go outside the local network are HTTPS, since they do go across the internet.

Redesigned User Interface (UI)

While in current state of a proof of concept, the HEMS could use an updated interface that more accurately reflect brand standards. A new UI on the HEMS could also allow for more advanced charts and controls of devices.

New Architecture Using Flowfuse

The current HEMS implementation utilizes Node-Red for the underlaying architecture. Updating this architecture to use Flowfuse would open up the opportunity for cross team collaboration and utilization of components, such as meter readings or end devices. This could allow for independent groups to develop independent programs (Demand Response, EV Subscription, Real Time Pricing etc.) and hardware integrations. Many of the current device implementations would import directly to Flowfuse with little to no modification necessary. This platform also improve scalability, because there is still much manual configuration done in the HEMS before it is stood up for each participant.

Alternative Communication Test Platform

The gateway can accept several communication card types and could be utilized to test communication technologies like private LTE or Amazon Sidewalk.

New Hardware Design

The current HEMS is running on an x86 single board computer called the Duke Energy Gateway. This is currently being evaluated for a hardware upgrade to and ARM based single board computer. The new hardware would be more cost effective, energy efficient, and would be able to communicate with more smart devices (Zigbee/Thread). Running the HEMS on the ARM based processor would take some modification to some of the software packages in use, but majority of those software packages have ARM compatibility.

Utility Management Interface

Currently the only connection to the HEMS from Duke Energy is the OpenADR 2.0B interface. It is mostly utilized in a one-way fashion for sending control events. A utility management interface for the HEMS would be beneficial for aggregation of curtailable load and for target geographically demand response events. The additional information returned could be used to help design future programs or to target participant with specific appliance or electric vehicles.

EMCB Local Interface

The current EMCB local API has only just received its first update in several years. The current release is in an alpha stage (not suitable for production) and had many memory leaks and would sometime drop commands due to the UDP structure. The EMCB local communications were built in another separate containerized application, and it made it difficult to incorporate some of the features into the HEMS. To improve reliability the HEMS should have this code natively contained within the HEMS application. At the same time the local EV EMCB commands could be directly incorporated into the HEMS as well.

OpenADR 3.0

Update the OpenADR 2.0B spec to OpenADR 3.0.

Pilot Continuation

- Small Internal Pilot
- External Pilot
    - Increased security
    - Requirements
    - Less setup
    - Additional staff
    - Improved OpenADR implementation

Conclusions

While the HEMS accomplished the goals initially targeted, there is vast room for improvement in the smart devices and architecture that would need to take place before expanded further. As more smart devices become standardized by using things like the matter protocol, natural growth, device inclusion and system impact (more kW) would be improved.

While Node-RED/Node.js is excellent for rapid prototyping integrations and control there are other languages such a Golang that could result in much better performance and lower memory utilization. While performance was not an issue in this proof of concept, if the HEMS was to support more devices and more algorithms, performance could become an issue.

Many times, the communication path with certain devices had to be through a cloud. If continued beyond a proof of concept / pilot, making it a requirement to have the hardware used with the HEMS communicate locally is very important for the sake of reliability.

- Empowers customers to make informed decision on their energy use by adjusting behaviors
- May increase likelihood to participate in demand response programs
- Helps customers under their bill better and allows for more transparency on their total bill cost
- Keeps customers more engaged

Utility: DUKE ENERGY FLORIDA, LLC.
Program Name: Low Income Weatherization Assistance
Program Start Date: May 2000 with modifications approved in 2005, 2015, 2017 & 2018
Reporting Period: 2024

($138) Net Benefits	NPV Avoided T&D Elec	NPV Cost-Based Avoided Elec Production	NPV Cost-Based Avoided Elec Capacity	NPV Net-Fuel Lost Rev Elec	NPV Administration Cost	NPV Implementation Cost	NPV Other Utility Cost	NPV Incentives	NPV Participant Cost (net)	NPV Participant Cost (gross)
$ (137,627.65)	$522,515	$362,461	$452,350	$1,105,146	$0	$154,557	$0	$215,250	$0	$0