Product Council Series

Hosted by: Emerging Technology and Product Management

How Will All These Smart Appliances Talk to the Smart Grid?



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e-Radio UMC – Utility Message Channel

By Jackson Wang, P.Eng. e-Radio USA Inc. Oct 3rd, 2023



CTA 2045 history and mission

- 1. Past attempts at plug/play
- 2. Appliances; proprietary plugs (AOS, Rheem, GE, etc)
- 3. EV (ODB II)
- 4. External Switches for resistive WH
- Video of early CTA: e-Radio NPR, EPRI Youtube Video
 - https://www.youtube.com/watch?v=RGy0GTMLdYQ

Past and current projects

- 1. BPA arch and full detailed report
 - <u>CTA-2045 Water Heaters Bonneville Power</u> <u>Administration (bpa.gov)</u>
- 2. EV example from CTA UCM: XPERI & TX video
 - https://youtu.be/9UnGJ8Y5jD4
- 3. WatterSaver w AEA/PG&E
 - LTE UCM w/ FM/RDS/HD
- 4. HPWH OEM
 - ALU

Economic Realities

1.Supply chain health

- HW build
- SW integration and support
- Comm issues: coverage, reliability, costs

2. Scale needed

• valley of death

3. Vision going forward

- Pooled inventory
- Pooled resources to OEM and aid field deployment

Sample of Utility direct load control Installation from ~2006



FMresponsive Appliances



Pre-production FM- responsive dishwasher and refrigerator (2008)

FMresponsive EVs

FM RDS for Smart Charging of PEVs

· Road vehicles plenady have an optimized and pre

broadcast receivers

established communication channel in place: FM radio

. Many new FM radio head units have the Radio Data

 Coverage and infrastructure installation cost issues facing other lachrological standards are addressed by large public. FM Radio networks, such as the Public Radio Salellile System (IPRSS) in the U.S., the CBC in

Canada, and the BBC in the UK as well as privately-

. The coverage of New York State strown here is an ex-

owned FM networks that offer additional and reduc coverage of most geographic markets.

ample of extensive coverage already in existance

System (RDS) hardware and software built in

1. Motivation



2. Architecture



 Electricity pricing and load control information originates at the power utility or an independent system operator (IBO) and is sant, for example, by OpenADR XMII, to the e-Radio aggregator server.

 e RAdo I kanatas fre utilitytillS (Imat Energy Portle (SEI): 1.0 wai implemented on the prototype due to availability revealages unge anagong end compression algorithm into a format subletie to ene-my lose basebacht broadcauting (e Rado I M ROS Utility Manago Channel of UAR) and finitids free missages to the e-Rado data casting relever.
 Mesiages and datababat to the FM translates vai thereistrial individual data for statilite entrocks to where the M ROS cisia is embedded within 5144's assumed for the existing M maximum.

 FM RDS capable receivers capture the aignal and data within the large coverage area of the station transmitter; how ever, only the e-Raitio prototype is capable of decading the EV-specific converseds for the vehicle.

June 2012 EV project & IEEE ITEC paper

3. Design of the Prototype



 The protrippe is executed as an on-board stand-alone FM HDS gateway that plugs into the existing vehicle Controller Area Network (CAN) bus via a diagnostic port connector

 The dedicated e-Radio FM RIDS receiver allows other broadcast data applications to reach the vehicle bos in addition to EV changing control protocol (like emergency rotifications)

 The gateway prototype expands the compressed metsages from e-Radio FM RDS format to CAN bus frames after recaption

 The gateway CAN interface also manages the necessary flow-control parameters for multipart messages and the responses to messages on the bus

 Existing standards for EV charging including SEP 1.0, BAE 2047/1 and SAE 32636/1 provided the basis for the prototype CAN bus meissages

4. Message Mapping / Compression



5. Summary

FM RDS was successfully demonstrated as a viable solution for control of EV changing

 Last control (an immediale net-ottor in charging poner usage) and update of time-of-use potcing tables (affecting both current and African charging schedulism) were both successfully devortanted using a taske task (EV charging control messages in accordance with SEP 1.0, SAE J26471 and SAE J26301 Va a the FM RDS charmel (CBD in Tommb) to an EV in the field.

e-Radio plans to undertake real-world validation of the smart-grid impact (economically and technically) of FM RDS is cooperation with utilities, standards bodies and broadcasters

e - Radio

FMresponsive Heat Pump Water Heater



HPWH responsive to KUDL FM in Sacramento, July 7th 2021

FMresponsive Thermostat



2007 & 2021 FM Open ADR Thermostat in Sacramento

Programmable Communicating Thermostats

PCT installed in homes and businesses in CA, TX, ON





ANCI/CTA 2045 examples











EV smart charging

- Partnership w XPERI CTA-2045 DC UCM
- (EVSE) SAE J1772 (EVA
- plug) NACS compatible







First FM RDS-TMC broadcast in North America







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FM GHG broadcast in Sacramento



KUDL FM RDS & HD March 12, 2021



Fleximax: FM as carrier of European grid info

- e-Radio is working with EU Fleximax project towards sharing information and leveraging common solutions towards global scale
- Active advisors on NA/EU collaboration on with LBNL connection
- Radio France as radio carrier and possible public disclosure events





FM as carrier of Texas Grid info

- KUT University of Texas at Austin FM station authored a series on the Texas Grid:
- <u>https://www.npr.org/podcasts/</u> <u>1004840920/the-disconnect-</u> <u>power-politics-and-the-texas-</u> <u>blackout</u>



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SkyCentrics Smart and Connected - NEEA 2023



Stake Holder Overview

How to Scale?





AGGREGATORS



































How Open Standards Help – But you need the port!







- Competitive Pathway to Devices
- Future Proofs (swap out module)
- Can function as Universal Remote
- Add Functionality More Easily



SkyCentrics Products and Services









EcoPort

SkyBox





CTA-2045 EcoPort Updates

CTA-2045 Certification & QPL



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ECOPORT

Consumers, utilities and aggregators now have a growing selection of appliances or control modules that can participate in programs which minimize electric grid costs or leverage renewable energy availability.

EcoPort is the brand name for CTA-2045 certified products.

Buy the test tool here.

How does EcoPort work with OpenADR? See an explanation HERE

Supplemental Info

emental

Certification & Branding





Latest News

- <u>OpenADR Momentum & Ford</u>
 <u>Joins Board of Directors</u>
- <u>Alliance to showcase</u>
 <u>OpenADR EV, DER & DR</u>
 <u>Solutions</u>
- <u>AMPECO and OpenADR</u>
 <u>Alliance partner in Europe</u>
- First Certified EcoPort

CTA-2045 OEMs

SkyCentrics AC Powered EcoPort module	SkyCentrics DC Powered EcoPort module		
SkyCentrics WN: 20F85ED3A189 Example KNWAKKA Mail UlarZA Mail UlarZA Mail UlarZA Mail UlarZA	SkyCentrics s/n: 20F85ED33B8F code: BE4B2F Mdi: US03A 23.2016		
AO Smith – Electric Resistance Water Heater	Siemens EVSE Car Charger		
AO Smith – Heat Pump Water Heater (HPWH)*	Mitsubishi Mini-Splits		
IslandAire PTAC HVAC units	GE Appliances – Heat Pump Water Heater		
Pentair IntelliConnect Pool Pump Controllers	Bradford White – Heat Pump Water Heater		
Rheem – Heat Pump Water Heater*	Nyle – Water Heater (110V heat pump)		
Mitsubishi QAHV – Central System HPWH	Emerson 30 Amp Water Heater Switch		
Mitsubishi VRF			
Harvest Thermal – Heat Pump HVAC and water			
WaterDrop – Commercial Water Heater			
Intellihot – Commercial Water Heater			

CTA-2045 **ECOPORT** appliance family





Heat Pump HVAC Mini-splits
CTA-2045 **ECOPORT** appliance family







Pool Pumps

EV Chargers

SIEMENS

Load Shifting

- Stores hot water for 8 hours
- Can Load Up
- Can Advanced Load Up and store more

Load Shaping-Frequency Response

- Variable Power between 0-100%
- Frequency Response Possible No damage to product from rapid changes

SkyCentrics EcoPort Communication Options





FM Radio (e-Radio)





SkyCentrics SkyBox Options

SKU 1



SKU 1a





CTA-2045 EcoPort to Modbus/BacNet CTA-2045 EcoPort to Modbus/BacNet 24V powered RS-485 ports



Projects using EcoPort and SkyBox

SkyCentrics DREAM Platform





Cal Flex Hub Projects









Day Ahead 24 hour price shapes

Cal Flex Hub Projects



Table 2. Potential Unit Impacts¹¹ Based on Literature Review and End-Use Metering

Navigant	
Cost-effectiveness)
of DR for	
Residential	
End-Uses	

0.09 kW				
per heat pump				
Water heater				

0.61 kW per Pool Pump

Appliances	Enabling Device	DR Strategy	Phase 1 – Literature Review ¹² (KW)	Phase 2 – Baseline Study All Days (kW)	Phase 2 – Baseline Study Hottest Days (kW)	Estimated Unit Impacts ¹⁵ (kW)
Central Air Conditioner	Wi-Fi thermostat	Temperature setback	0.71	0.35	0.85	0.71
	Built-in	Temperature setback	0.08	0.05	0.13	0.13
Room Air Conditioner	Simple timer plug	DLC	0.06	0.05	0.11	0.11
	Wi-Fi plug	Temperature setback	0.06	0.04	0.09	0.09
Clothes Washer	Built-in	DLC	0.02	0.00	0.00	0.00
	Simple timer plug	DLC	0.02	0.00	0.00	0.00
	Wi-Fi plug	DLC	0.02	0.00	0.00	0.00
Clothes Dryer	Built-in	DLC	0.06	0.04	0.04	0.04
Dishwasher	Built-in	DLC	0.01	0.01	0.01	0.01
Refrigerator	Built-in	Deferred defrost	0.03	0.05	0.05	0.05
Reingerator	Wi-Fi plug14	DLC	0.05	0.05	0.05	0.05
	Built-in	DLC	0.20	0.13	0.14	0.14
Dehumidifier	Simple timer plug	DLC	0.17	0.08	0.10	0.10
	Wi-Fi plug	DLC	0.19	0.09	0.11	0.11
Ductless Heat Pump/Air Conditioner	Wi-Fi thermostat	Temperature setback	0.05	0.10	0.25	0.25
	Built-in	DLC	0.13	0.10	0.09	0.09
Heat Pump Water Heater	Simple timer switch	DLC	0.13	0.10	0.09	0.09
	Wi-Fi switch	DLC	0.13	0.10	0.09	0.09
1	Built-in	DLC	0.27	0.17	0.16	0.16
Electric Resistance Water Heater	Simple timer switch	DLC	0.27	0.17	0.16	0.16
	Wi-Fi switch	DLC	DLC 0.27 0.17	0.16	0.16	
	Built-in	DLC	0.58	0.46	0.61	0.61
	Wi-Fi plug ¹⁵	DLC	N/A	N/A	N/A	N/A
Pool Pump	Simple timer switch	DLC	0.58	0.46	0.61	0.61
	Wi-Fi switch	DLC	0.58	0.46	0.61	0.61
Battery	Built-in No- Solar	DLC	N/A	0.86	1.37	1.37
Storage	Built-in Solar	DLC	4.00	N/A	N/A	4.00
EVs ¹⁷	Built-in EV	DLC	0.09	N/A	N/A	0.09
(Home Charging)	Wi-Fi EVSE Controller	DLC	0.09	N/A	N/A	0.09
	OBD Dongle	DLC	0.09	N/A	N/A	0.09
	EVSE Built-	DLC	0.09	N/A	N/A	0.09



Pool Pump SMART Event Behavior





Pool Pump SMART Event Behavior





Cal Flex Hub Projects

CalFlexHub Low Cost Cellular to Wi-Fi for DAC







Gas Demand Response Proposal for Multi-Family, Hotel, Commercial **Pool Heaters**





Gas Demand Response

Optimize Pool Heater to weather: Outdoor Air Temperature, Solar Gain



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≪ Dashboard	Dashboard Devices Docs/Data	Floor plans Net Zero DR Reports	≩ CEGY	Powered by SkyCentrics
Devices	+ Search 🔽	Lap Pool		MAC Group (Go to) Last Update dos632#8595 La Mesa YMCA 06/23/022 01:11:19AM
 Docs/Data Floor plans Net Zero DR Reports 	 Search La Mesa YMCA Lap Pool Santee YMCA Activity Pool Lap Pool Spring Valley YMCA Indoor Pool Spa Outdoor Pool 	Lap Pool Historical ✓ Temperature (?) × × ✓ TEMP 85 80	Disaggregated V Custom range V C 5/23/2023 POOL & OSA TEMPERATURE	MAC Group Gate Last Update da632a85F5 La Mesa YMCA Da/23/2023 01:11:19AM - 5/23/2023 D > 5 (min) 2 - Pool Temp - OSA
		50 5:00 6:00 7:00 8:00 9:00 10:00 1 PM PM PM PM PM PM PM PM	1:00 MAY 1:00 2:00 3:00 4:00 5:00 6:00 7:00 PM 23 AM AM AM AM AM AM AM AM AM	8:00 9:00 10:00 11:00 12:00 1:00 2:00 3:00 4:00 AM AM AM AM PM PM PM PM PM PM

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Savings about \$5,000 per year for average 20' x 40' pool, and can do gas DR

Connected Communities Project













Multi-Family is a sweet spot



Cellular

0

0

V





Garden Style

126 apartments – 6 per building 21 buildings Solar + Battery + 126 ECOPORT water heaters 100 apartments Low Income Central System

Highrise







Commercial Equipment Now Here



Shiftable Water Heater Load = 20,000 watt-hours



Hawaii is providing \$2,000 per water heater in Multi-Family developments...

... if the water heater can be

shown to be controllable

by a solar array.

That carport has a direct link to controlling 140 water heaters.





Utility Focused Part of the Platform

How Utilities Send SkyCentrics Signals (again)



How we send signals to buildings



GEBTool Grid-Interactive Efficient Buildings (GEB)

Grid-Interactive Efficient Buildings (GEBs) could save up to \$18 billion per year in power system costs by 2030, or roughly **\$100 to \$200 billion** between 2020 and 2040



...but less than 2% of commercial buildings are connected! GEBs are characterized by active, continuous, and integrated energy use



Figure source: Neukomm et al. (2019). Grid-interactive Efficient Buildings: Overview. US DOE Report.

A National Roadmap for Grid-Interactive Efficient Buildings

Source = A National Roadmap for Grid-Interactive Efficient Buildings - gebroadmap.lbl.gov

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Whole Building Meter Analytics



- 40,000 sq. ft multi-tenant office building
- Historical electricity meter data since 2015
- Track real-time usage and historical patterns
- Manual and automated alerts



Predictive Analytics

SkyCentrics Analytics Infrastructure



Multiple data streams

Flexible and scalable data ingestion



Anomaly detection

Diagnostics and fault detection



Real time analytics

Continuous data analytics in real time



Actionable insights

Operations automation and maintenance



Predictive analytics Comfort and energy efficiency optimization We connect to these DERs, and can connect to any DER by API, EcoPort, or SkyBox





By making it easy to migrate, we get lifelong customers

Project Haystack

Open Standard Independent Data Layer



Multi-cloud Able to easily migrate Easy access by API Other open formats available (Brick, etc.)

Ecosystem Design Evolution*

The transition to open data sharing ecosystems will enable new adaptive systems that leverage both data values and new solution delivery relationships

Command & Control



Single Vendor Proprietary





Multiple Vendors Coexist

Open Data Ecosystem



Coexistence Evolves To Open Data Sharing

* Harbor Research Data Ecosystem Orchestrators, August 2022

Commercial IoT is 10 years behind Residential, but will end up in the same place



SHIFTED ENERGY

Connecting Smart Appliances to the Smart Grid

Leadership



Forest Frizzell

Co-Founder & CEO Leadership in Utility & Gov, 20+ year IT, SV Start Up



Olin Lagon

Co-Founder & CTO 11 patents. Serial Tech Entrepreneur/Innovator



Matt Motoki

Chief Data Scientist Electrical Engineer & World-Ranked Data Scientist



Jennifer Ignacio

Sr. Dir, Project Delivery DSM Project Development & Implementation CEM, LEED, AP



Chris Murphy

CFO ExecutiveFfinance, Multiple Cleantech Companies



Jonathan Howery

Sr. Dir, Client Success National Experience in DR & Energy Storage Markets

Mission

Shifted Energy helps utilities integrate clean energy, build customer trust and balance the grid through monitoring, optimization and customerfriendly load control.

Core Expertise

- Data Science & Machine Learning
- IoT Devices & Communications
- Scalable Software Architecture
- DER Forecasting & Optimization
- Underserved Community Engagement

Grid Maestro VPP

Multi-Asset Grid Interactive Buildings

- Any connected device & comms protocol
- Real-time telemetry, forecasts, and status
- Monitoring and control tailored to asset type, asset capabilities, and end users
- Integrate with any head-end utility system
- Web-based dashboard for rapid, low cost, hassle-free pilots
- Customizable eM&V reporting
- Scalable architecture



Machine Learning-Driven Aggregation & Optimization

Grid & Network Services

- 7 Day Ahead Forecasting
- Peak Load Reduction
- Permanent Load Shift
- Load Build / Renewable Firming
- Emergency Demand Response
- Fast Frequency Response

Residents & Building Managers

- Time-of-Use Optimization
- Maintenance Alerts
- Energy Efficiency/ Vacation Mode
- Demand Charge Management
- Solar Self-Consumption

Shared Stakeholder Value



Shifted Energy: Grid Service History

Dis covery Product Development • Energy programs engaging 3 mostly hard to reach homes • Piloting of over 700 endpoint market ready technology • 500 GIWH deployed w/ EEx, I and Hawai'i Energy • EEx Ideation Track Location / Endpoints • Oahu & Maui / 1,700 2016-17	,000+ s, 5 HECO,	 Grid Maestro System V Product Development GSPA 1 award and first deployments begin Work with Hawai'i Energy to focus on LMI recruiting Locations / Endpoints Oahu / 40 	71.0 ,	 Scaling Grid Maestro Product Development Field testing CTA-2045 on 65 gallon HPWH in partnership with Hawai'i Energy. Data share with HECO. Worked with Cadmus and HECO on eM&V project Contine GSPA deployments Locations / Endpoints Maui / 500 Oahu / 4,000 2021-23
Image: State	 2018 R&D to GM V0.9 Product Development Piloting multiple stacked grid services as lead up to GSPA IoT communications and ease of installation EEx Go To Market Track Locations / Endpoints O'ahu / 20 	f	 2020 Commercialization Product Development 2.5MW GSPA deployments co SE was the first contractor to any capacity on-line and held distinction for 2 years Tested FFR 2 with 90 V.2 Ara controllers in Partnership with EEx, and Hunt Development Locations / Endpoints O'ahu / 1,500 	ontinue bring that 1 HECO,

Load Control Switches: Tech Evolution

Load Controller Challenges

- Manufacturer Variations
- Evolving Communication Methods
- Installation Time & Cost

Past: Timers/ "Dumb" Direct Load Switches

- Analog Timers
- One-way Communication (On/Off)
- Costly Device & Installation
- Unreliable Communications



Present: "Smart" Devices

- Two-way Communication
- Low-Cost Device
- Machine Learning/ Forecasting
- Expert Installation Required



Future: BYOD

- Standardized Interface (Universal Communication Modules)
- Future-ready Communication
- Consumer Installation




Load Control Switches

Low-cost solutions for assets which are not already "smart"

- Complete control & analytics for older models
- Inclusive device solutions
- Integration capability in existing utility DR and thermostat programs

Variety of control alternatives

- Wired: 120/240VAC; 30/50/90A relay or low voltage contactor
- CTA-2045
- Plug-in: 120/240VAC; 30/50/90A relay or low voltage contactor
- +/-2% sub meter for current, voltage & frequency
 Integrated, Flexible IoT Communications
- Pre-provisioned for automated commissioning
- Near-100% asset uptime
- Integrated, world-class cyber security













Shifted Solutions: Grid Services

- Comprehensive aggregation and optimization
- Industry-leading range of available services
- Simple web-based portal
- Fully customizable grouping, dispatch and reporting



"We are so excited to work with Shifted Energy to support the deployment of grid-interactive heat pump water heaters in our communities. New to the efficiency portfolio, these smart devices will not only provide customers with energy bill savings, but also help to inform future grid flexibility programs in order to meet our clean energy and decarbonization goals" - *Caroline, Implementer*

Shifted Solutions: Maintenance Identification

- Issue identification based on device-level usage patterns and anomalies
- Detection capabilities for leaks, broken elements, breaker flipping, and operational inefficiencies
- Automated notifications
- Monthly reporting





Shifted Solutions: Program Design & Engagement

uvents." Yoh Kawanami, Co Director of Customer Energy Resources at Hawaiian Electric

Capacity

-

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Location 0

Chargers



Learn more www.shiftedenergy.com

Get in touch Jennifer Ignacio Jennifer@shiftedenergy.com

Select Utility Clients





Select Global Partners

incubatenergy

URBAN FUTURE LAB Ë LEMENTAL EXCELERATOR

(Energy)^{Lab}





SHIFTED ENERGY

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