AEP Ohio's Grid Modernization Efforts to Satisfy and Attract Customers

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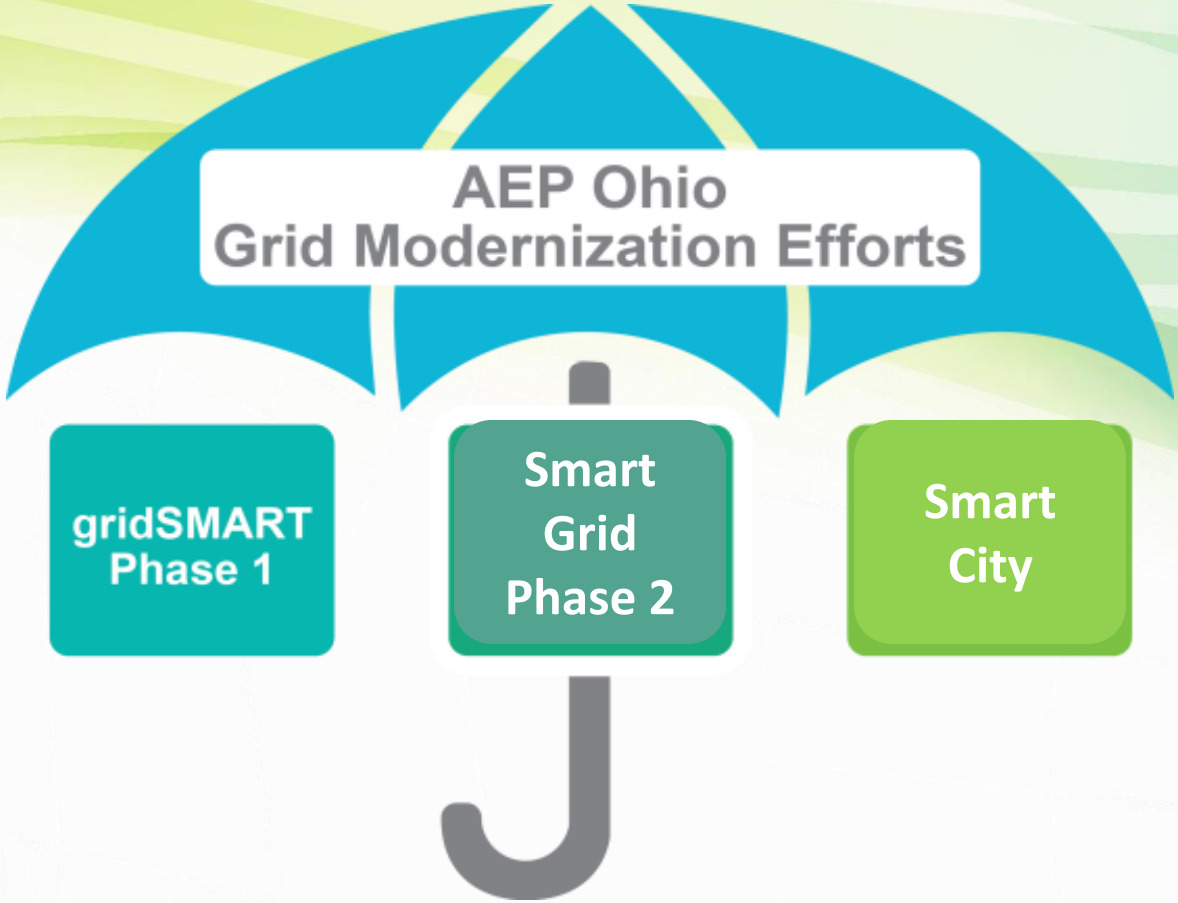
UEDA Summer Forum

Tuesday July 24, 2017

AEP Ohio's Grid Modernization Plan



gridSMART Phase 1 Technologies

AMI Meters –
132k Deployed

Volt Var Optimization – 17 circuits

Distribution Automation Circuit Reconfiguration (DACR) – 70 circuits

Consumer Programs – 10k participants

Customer Education and Outreach

Smart Appliances –
20 participants

Community Energy Storage – 80 CES units servicing appx 350 participants
(reduced to lab testing of 4 units)

Plug In Electric Vehicle – 10 unit demo with Level 2 Charging Stations

Cyber Security Operations Center

Northeast Central Ohio Area

AEP Ohio's Smart Grid Phase 2 Program

Distribution Automation Circuit
Reconfiguration
250 Circuits

Volt Var Optimization
160 Circuits

AMI Meters
894,000 Additional Meters

Significant Benefits

- AMI Meter-related labor reductions: $6 - 7M annually
- AMI Credit / Collections / Revenue Enhancements: $8 - 10M annually
- AMI Enables enhanced DR or time-differentiated pricing customer programs by CRES/DR providers
- DACR Targeted to reduce “Customer Minutes of Interruption” (CMI) by up to 30% (over 3-year average)
  - Estimated improvement of approximately 21 Million CMI per year* yielding customer savings of approximately $71M
- VVO Enables reduction of the average voltage that each customer on the circuit receives, thereby reducing the annual energy consumed by the customers on the feeder while maintaining and improving the quality of service to the end-use customer.
  - Reduction in energy consumption where deployed of appx 3%
  - Reduction in peak demand on circuits where VVO is deployed of approximately 2-3%

* For circuits serving approximately 330k customers in the project area. Results depend on weather.

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Benefit / Cost Analysis

	CASH VIEW		NET PRESENT VALUE VIEW**	
15 Year Benefits	O&M: Capital: Energy / Capacity: Reliability:* **TOTAL:**	$199 million $ 1 million $210 million $1.016 billion $1.426 billion	O&M: Capital: Energy / Capacity: Reliability:* **TOTAL:**	$103 million $ 1 million $ 102 million $519 million $725 million
15 Year Costs	O&M: Capital: **TOTAL:**	$148 million $368 million $516 million	O&M: Capital: **TOTAL:**	$ 83 million $282 million $365 million
15 Year Customer Impact	Net Cash Flows: Benefit/Cost Ratio:	$909 million 2.8	Net Cash Flows: Benefit / Cost Ratio:	$361 million 2.0

* Based on the "Cost of Power Interruptions to Electricity Consumers in the United States, Ernest Orlando Lawrence Berkeley National Laboratory" (2006)
** The Cash View reflects the nominal estimated expenditures and benefits related to the Phase II implementation. The Net Present Value (NPV) is calculated using an After Tax Weighted Average Cost of Capital (WACC) of 7.69%.

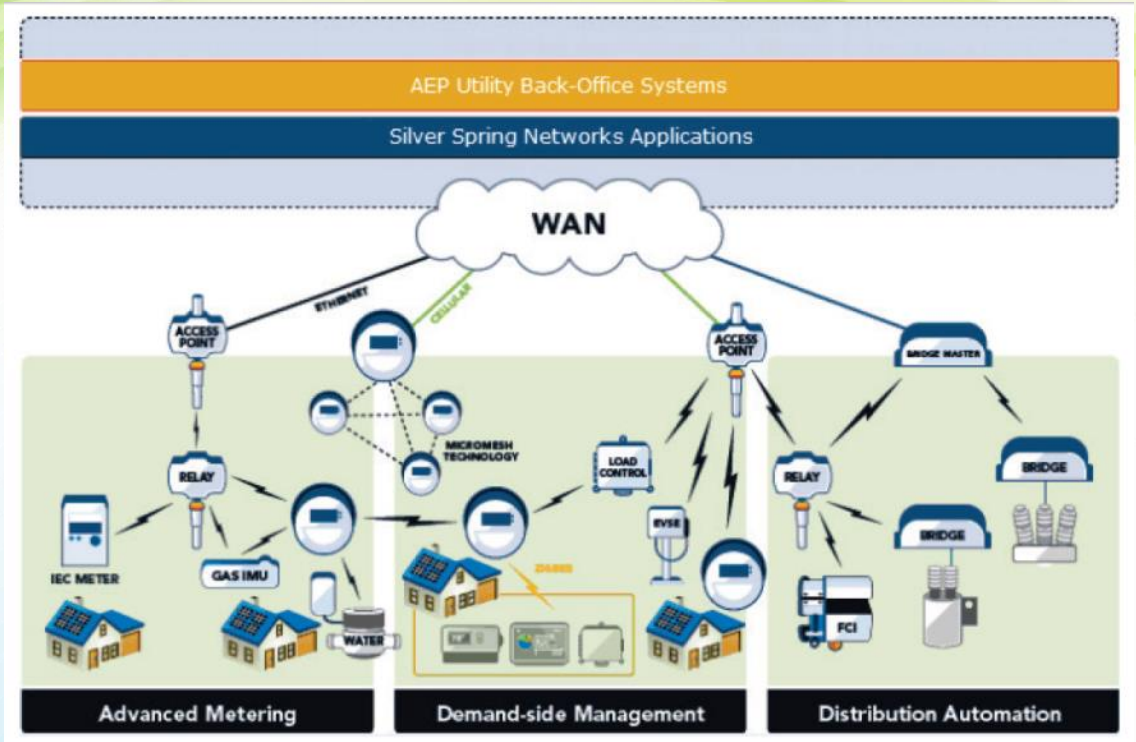
Note on Reliability: Customer Minutes Interrupted (CMI) and SAIDI are subject to impacts of weather

gridSMART Phase 2 Environmental Benefit Expectations

Program	Phase 1 Quantity	Phase 1 Annual CO^2 Avoided	Phase 2 Quantity	Phase 2 Annual CO^2 Avoided Estimate	Phase 2 Annual CO^2 Avoided – car equivalence
DACR Avoided truck rolls	70 DACR Circuits	11.24 metric tons	250 DACR Circuits	40.16 metric tons	9.13 cars
Consumer Programs Energy Reduction	Appx 10% of 110,000 customers with AMI	69.12 metric tons	Appx 10% of 894,000 customers with AMI	562.22 metric tons	127.78 cars
AMI Avoided truck rolls	From 110,000 AMI meters	202.92 metric tons	From 894,000 AMI meters	1,649.19 metric tons	374.82 cars
VVO Energy Reduction	17 VVO Circuits	12,536 metric tons	160 VVO Circuits	117,985.9 metric tons	26,814.98 cars

Advanced Metering Infrastructure (AMI)

894,000 AMI Meters to be installed
- Aclara Meters (formerly GE)
- Silver Spring Networks Communication System



SILVERSPRING NETWORKS

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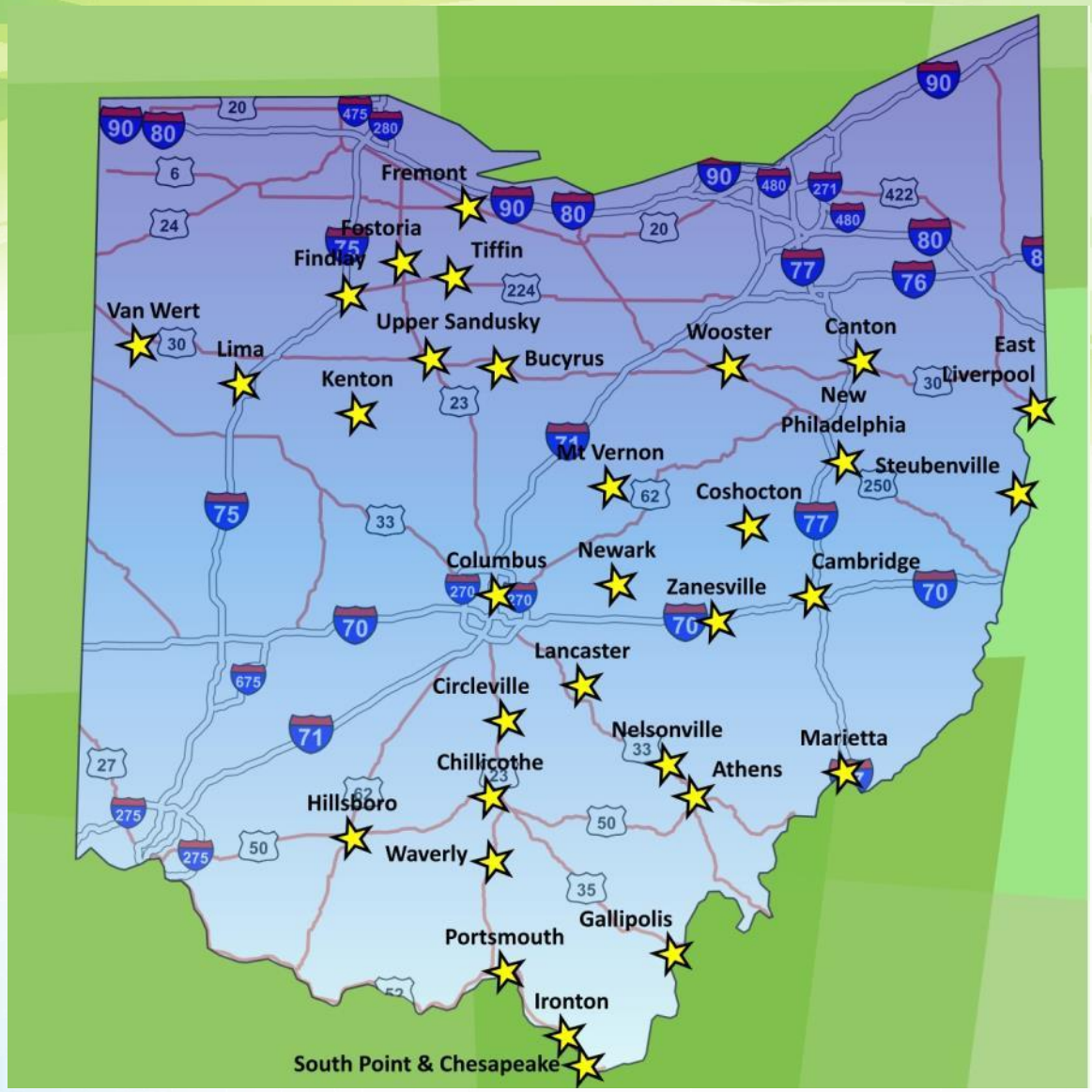
AMI Deployment Locations



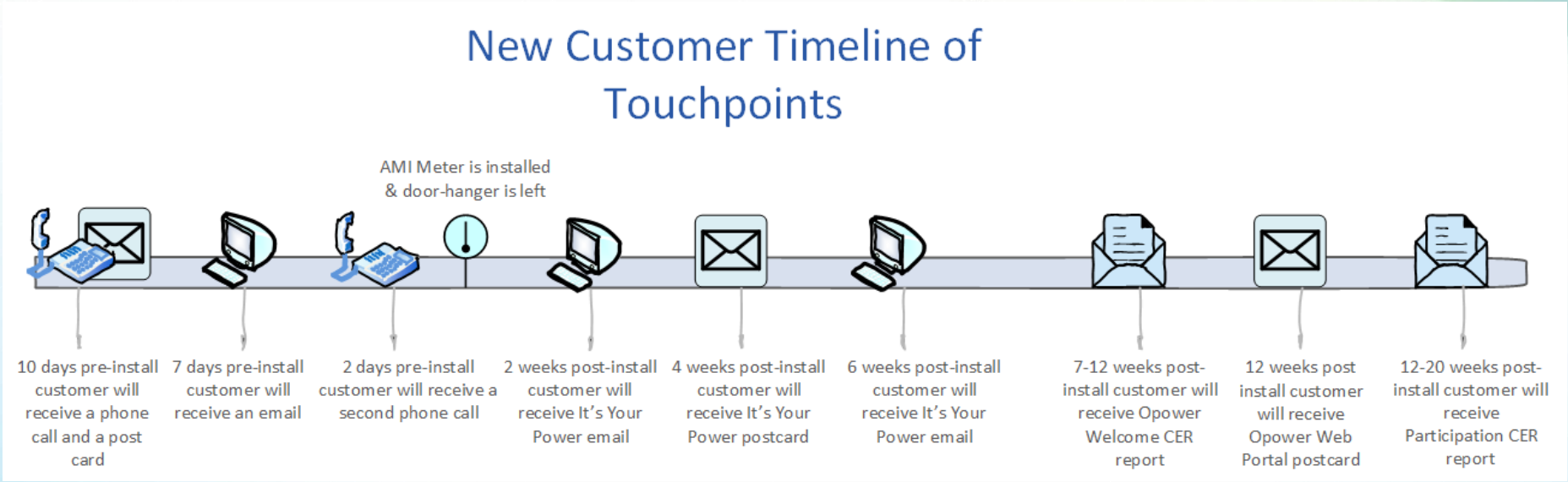
City	Estimated AMI Qty
Columbus	479,296
Canton	96,189
Lima	32,279
Newark	31,846
Zanesville	22,460
Findlay	22,363
Portsmouth	19,058
Lancaster	18,188
Steubenville	16,972
Chillicothe	15,241
Wooster	14,181
Fremont	11,171
Athens	10,347
New Philadelphia	10,017
Tiffin	9,918
East Liverspool	8,209
Fostoria	7,669
Cambridge	7,391
Cochocton	7,292
Marietta	7,235
Circleville	6,707
Ironton	6,671
Bucyrus	6,629
Van Wert	5,973
Kenton	4,282
Hillsboro	4,277
Upper Sandusky	3,539
Southpoint/Chesapeake	2,902
Gallipolis	2,750
Waverly	2,574
Nelsonville	2,505
TOTAL	894,000

Customers are the Focus

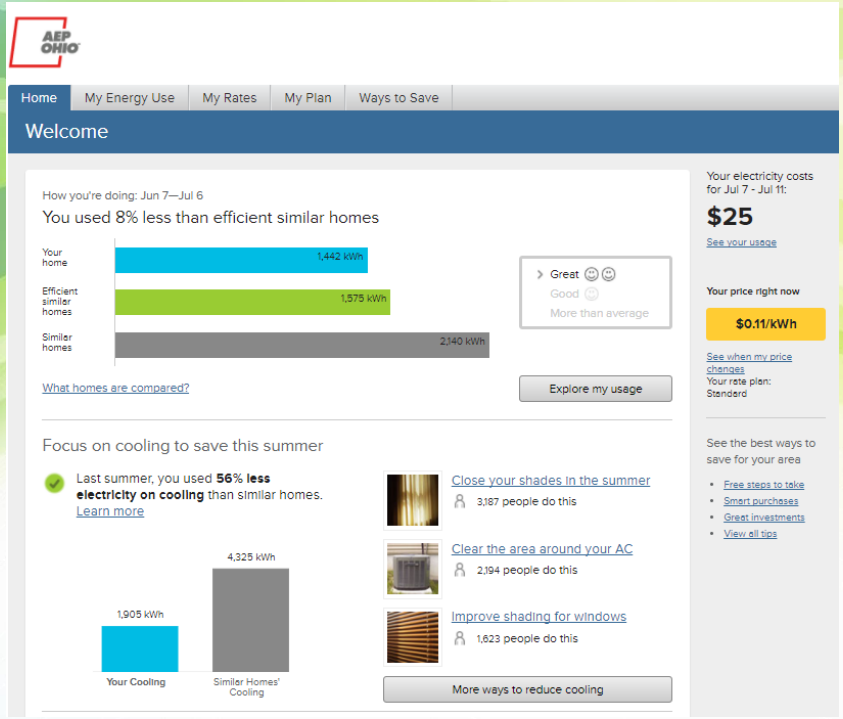
AEP Ohio Customer Communications

Plan for customer communications includes

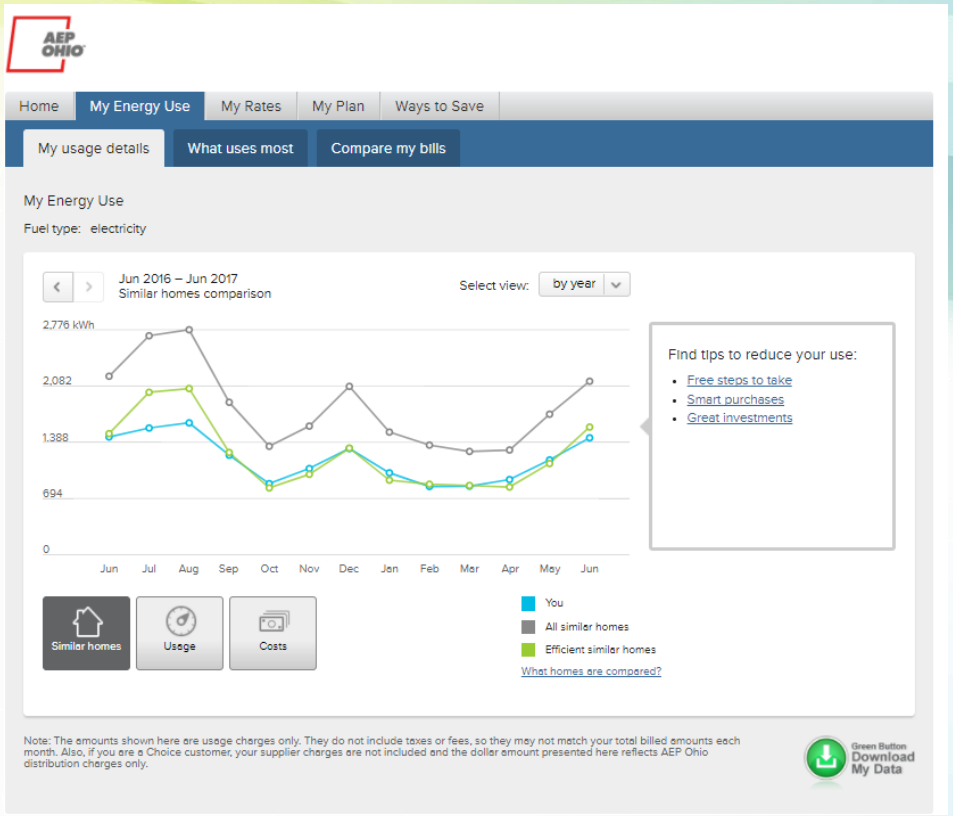
- Pre-deployment mixed media customer outreach
- Pre-install postcards sent to all residential premises
- Pre-install automated phone calls to all residential premises
- Door hanger when meter installed describing benefits to customer
- Post-install mailer on AEP-Ohio customer web portal
- Post-install mailer on AEP-Ohio smart phone app



Customer Web Portal



- Similar Home Comparison
- Rating
- Links to Tips

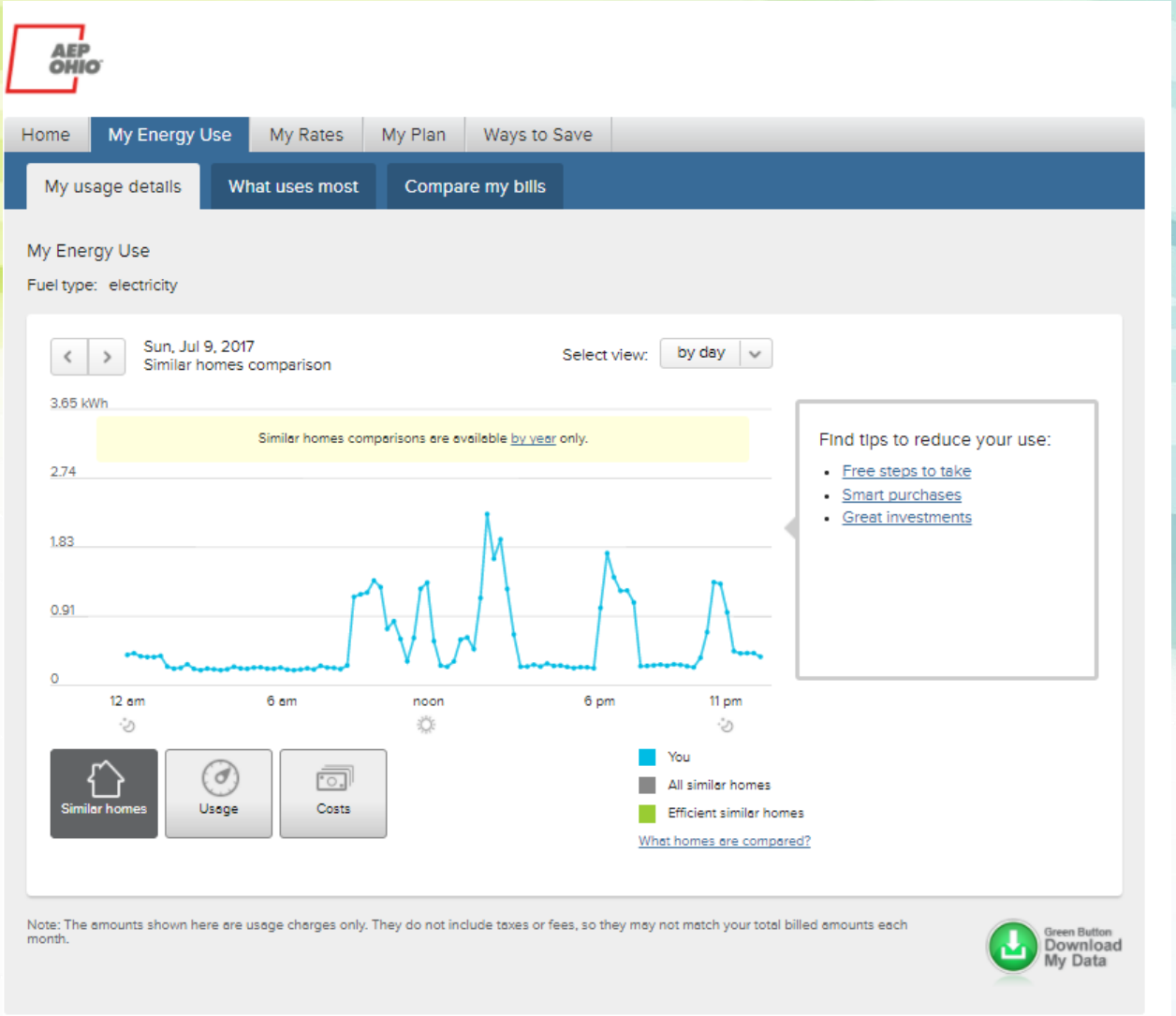


- Monthly Usage Comparison
- Green Button Download Link
- Links to Tips

Customer Web Portal (Hourly)

- **AMI Customers can login and view their interval usage (15 minutes)**
- **Drive usage behaviors**

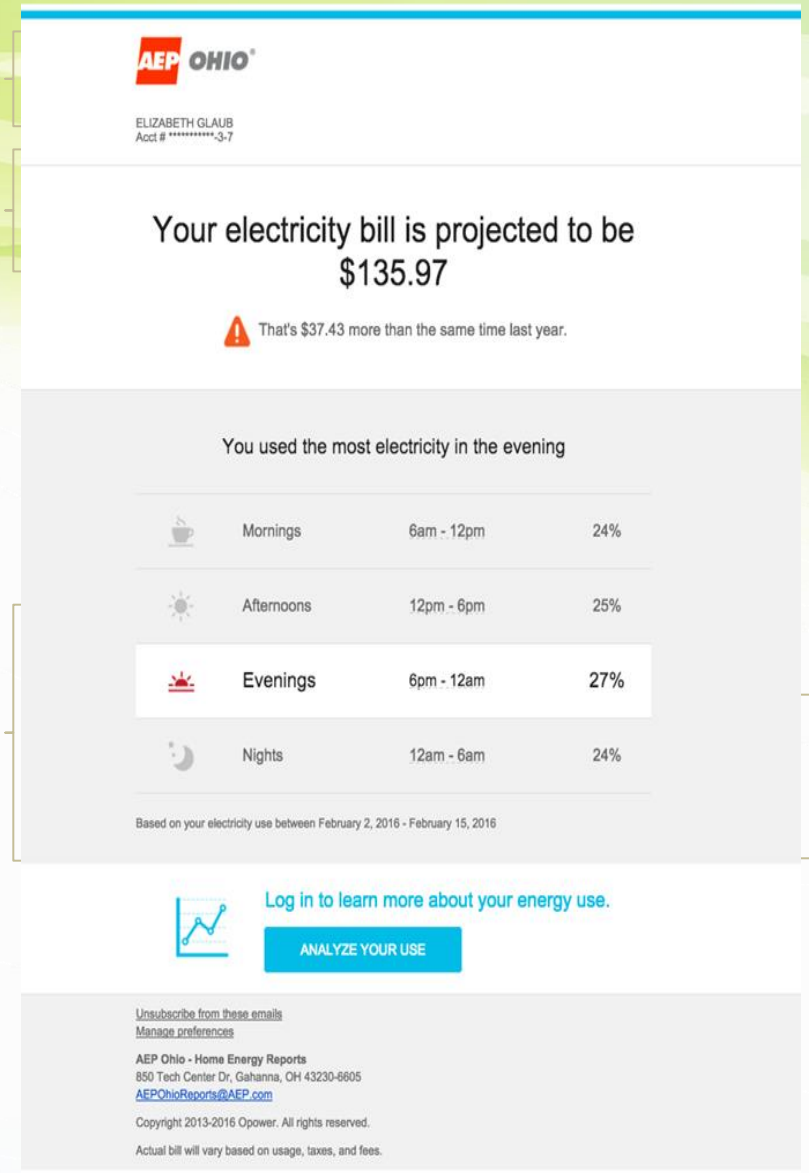
Green Button
Download
My Data ®



High Bill Alerts (AMI)

AEP branding

Ability to model and display cost information associated with usage



Bill forecast uses a time-series based predictive algorithm that takes into account both current and historical data to project energy use for the remainder of the billing period.

This algorithm has been optimized using the largest set of AMI, rate, and weather data in the world.

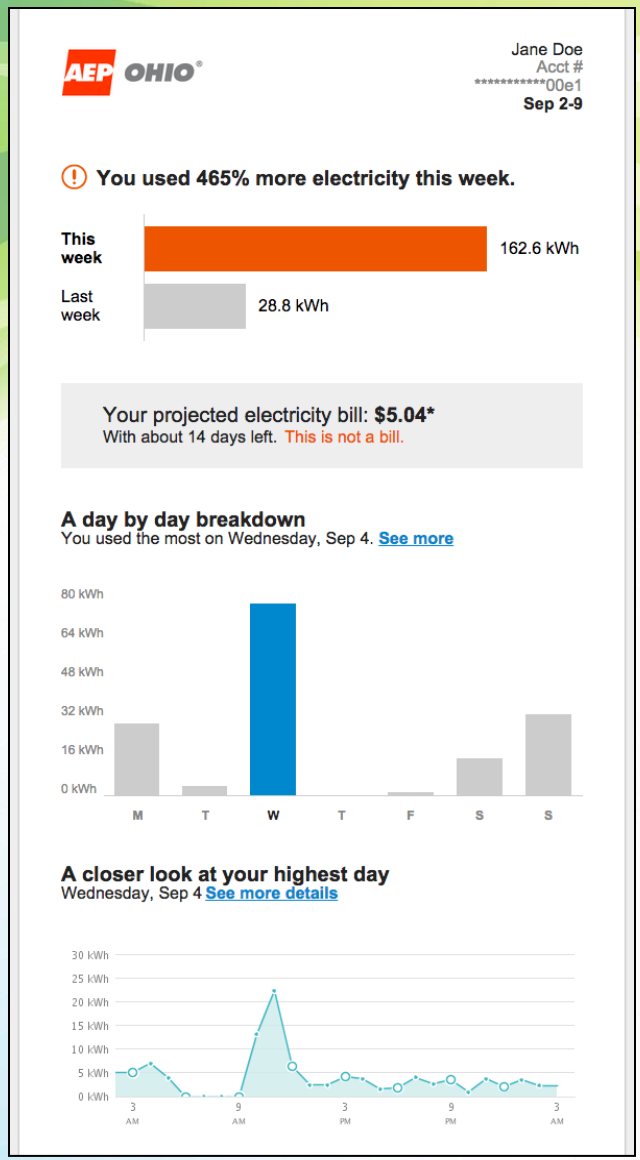
Analytics to display what time of the day each customer used the most energy

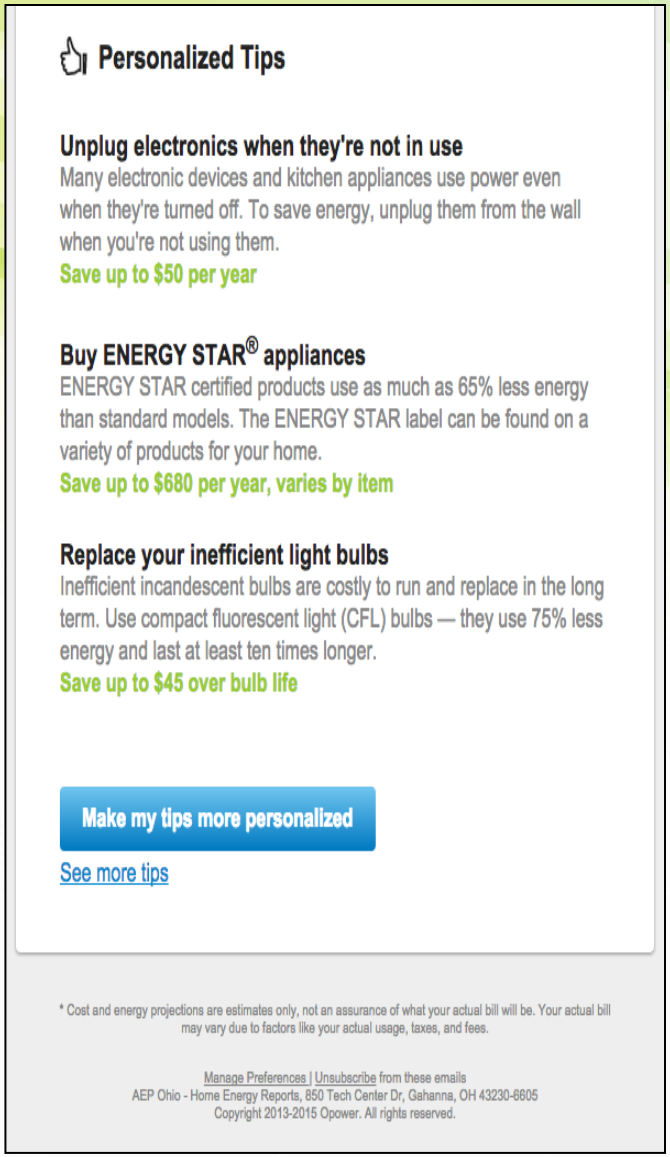
Segmentation and targeting generates personalize energy savings recommendations and program promotions (i.e. energy-efficiency, demand-response, and dynamic rate programs, services, and rebates)

Call to action pushes customers to self-service channels where they can learn progressively more about their energy use

Messaging is consistent and synchronized across channels for a seamless customer experience

Weekly AMI Insights (Opt In)





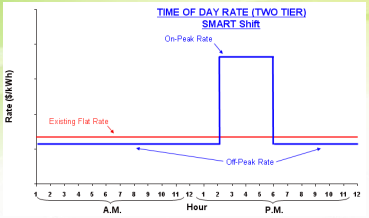
Support customer satisfaction to let customers know when they are trending towards a high bill and how they can adjust their energy use before the end of the billing period, reducing bill shock and associated calls into the call center.

Provide enhanced customer care functionality to all active AEPO AMI customers

Smart Grid Programs & Tariffs

Tariffs

SMART Shift[SM] – 2-tier TOD



SMART Shift Plus[SM] – CPP

SMART Choice[SM] RTP-da

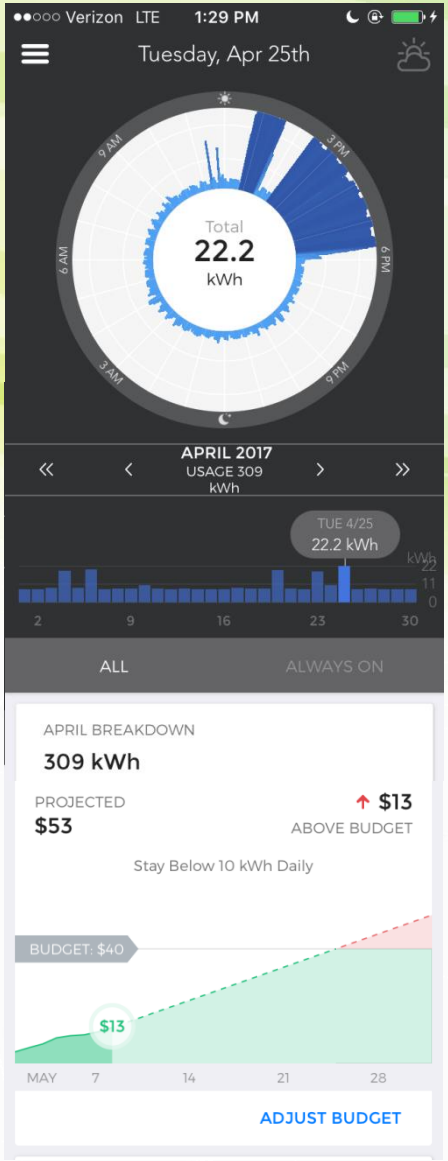
Programs

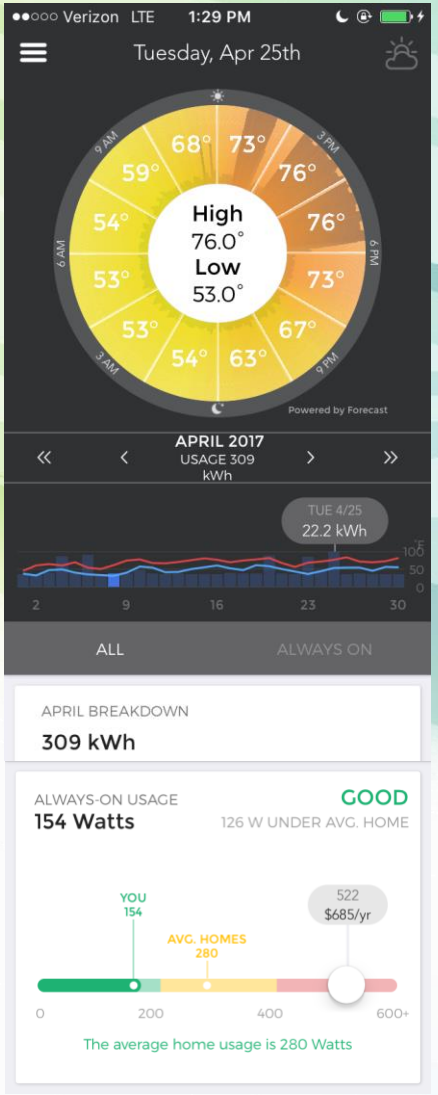
SMART Cooling[SM]–Programmable Communication Thermostat

SMART Cooling Plus[SM] – Load Control Switches (LCSs)

eVIEW[SM] – in Home Displays (IHDs)

It's Your Power App





Smart Grid Mobile

Smart Grid Phase 2 Customer Engagement

QUICK TURN DISPLAY

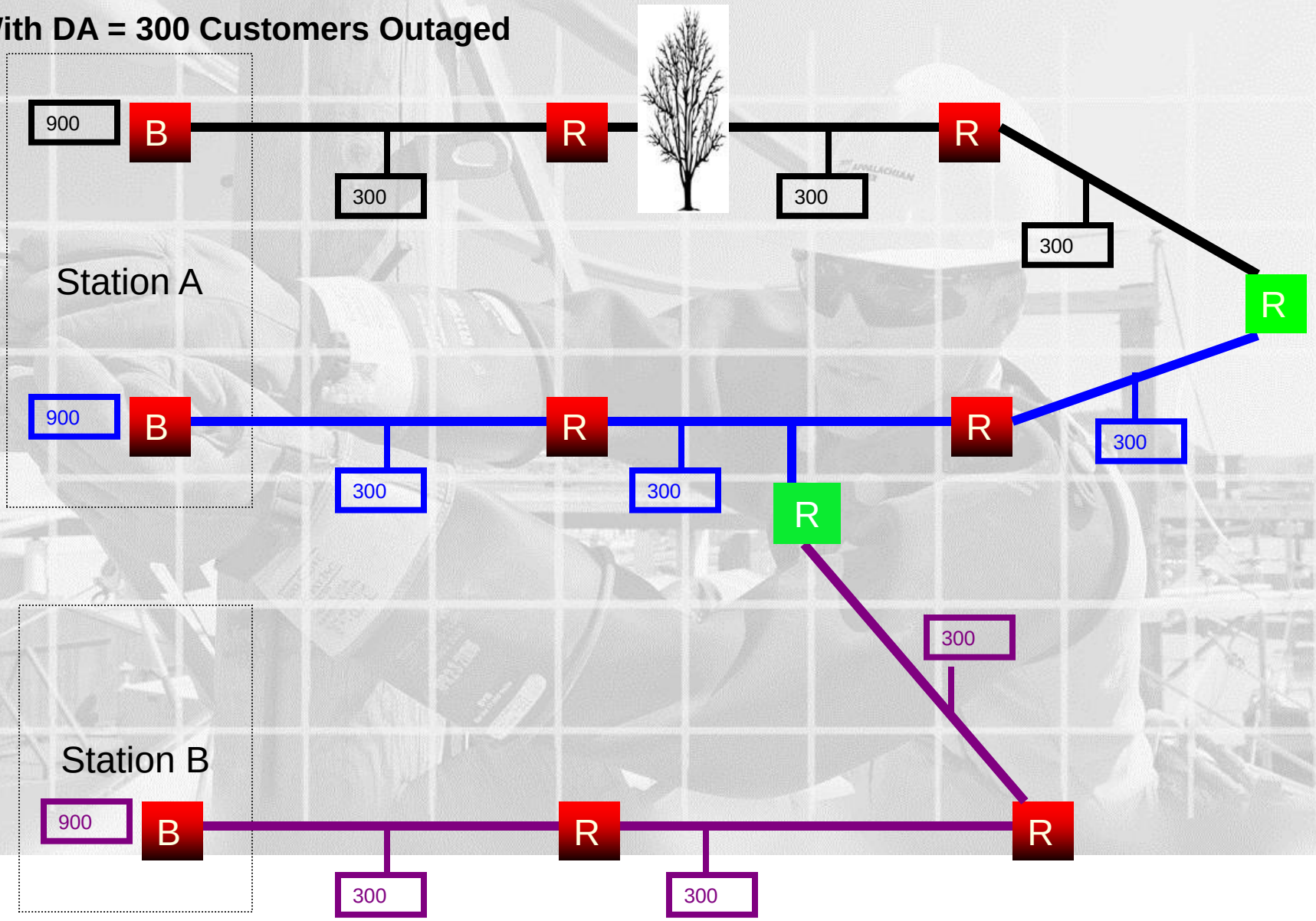
20'x10' Tented Display – Mid-July Launch

Distribution Automation Circuit Reconfiguration (DACR)

- Deployment: 250 circuits across Ohio, consisting of 13 kV and 34.5 kV distribution
- All circuits completed within 6 years
- Vendors: SEL and G&W Reclosers
- Telecommunications Network: TBD
- Targeted Deployment area: Ohio service territory with max benefit
- SAIFI Improvement target of >15.8%
- Phase 1 System has saved 11,456,905 customer minutes of interruption time for more than 135,000 customers *.* Based on data through 3/8/17

Permanent Fault

With DA = 300 Customers Outaged



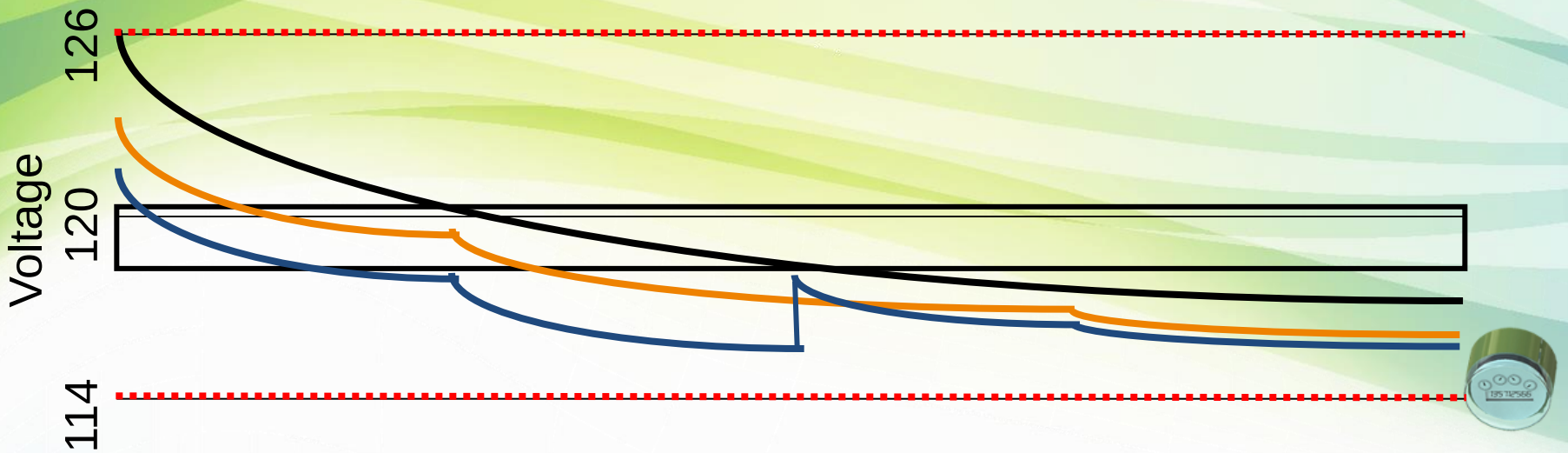
Volt VAR Optimization (VVO)

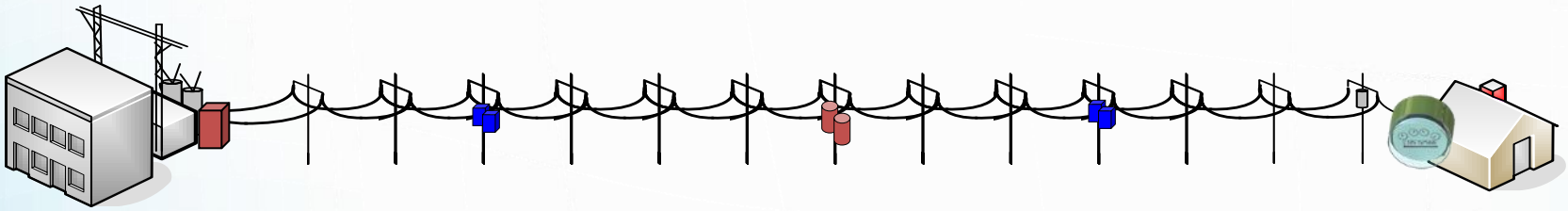
- 160 circuits across Ohio, consisting of 13 kV and 34.5 kV distribution
- All circuits completed within 6 years
- Vendors: Utilidata
- Telecommunications Network : TBD
- Targeted Deployment area: Ohio service territory with max benefit
- Target benefit EE >3%

Utilidata

EPRI Slide

Volt VAR Optimization





Distance from Substation

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SMART IS JUST THE START:

AEP Ohio's Smart City Overview

June 2, 2017 Columbus, OH

What is the Smart City Challenge?

U.S. Department of Transportation

The USDOT has pledged up to $40M to help Columbus define what it means to be a "Smart City "

Vulcan has pledged $10M to Columbus to help it increase use of electric and other alternative vehicles with low- or zero emissions

AEP OHIO

Dot smart city challenge
We won the job to become a smart city

1,400 local officials, companies, academics and non-profits joined our webinars

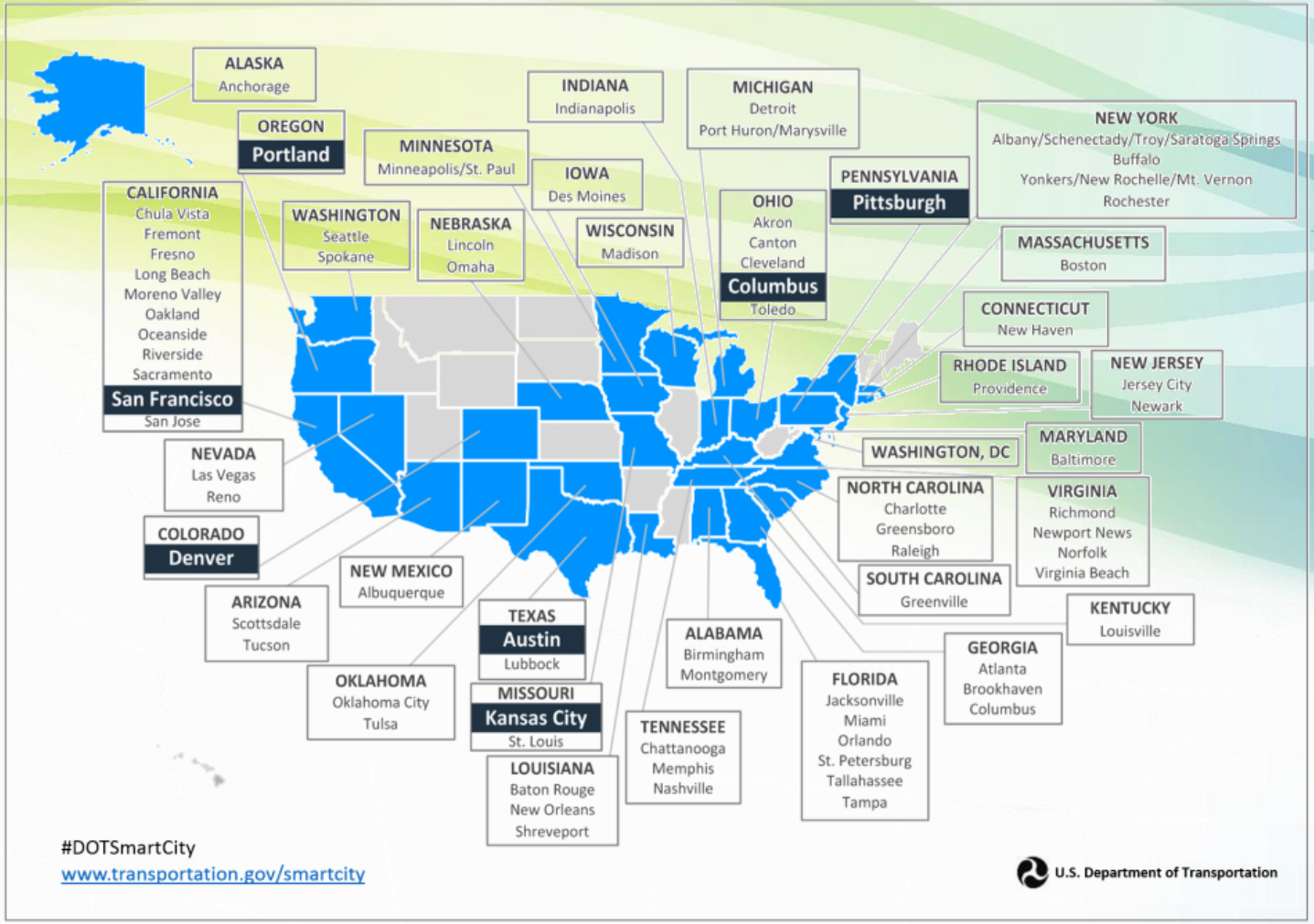
800 people participated in our Smart City Forum

300 companies have expressed interest in partnering

78 applications received for the Smart City Challenge

7 Smart City Challenge Finalists announced in March at SXSW

1 Smart City Challenge Winner announced in June



Picked to lead

SUMMARY

Beating out 77 other cities, Columbus won the U.S. Department of Transportation's Smart City Challenge, earning us a coveted global platform to demonstrate for the world what the future can look like.

78 APPLICANTS

7 FINALISTS

- Austin
- Columbus
- Denver
- Kansas City
- Pittsburgh
- Portland
- San Francisco

1 WINNER

DEPARTMENT OF TRANSPORTATION · UNITED STATES OF AMERICA — $40 M

VULCAN — A Paul G. Allen Company — $10 M

COLUMBUS $90 M

TOTAL $140 M

JUNE 2016 - COLUMBUS WON THE U.S. DEPARTMENT OF TRANSPORTATION'S SMART CITY CHALLENGE


FORTUNE SUBSCRIBE

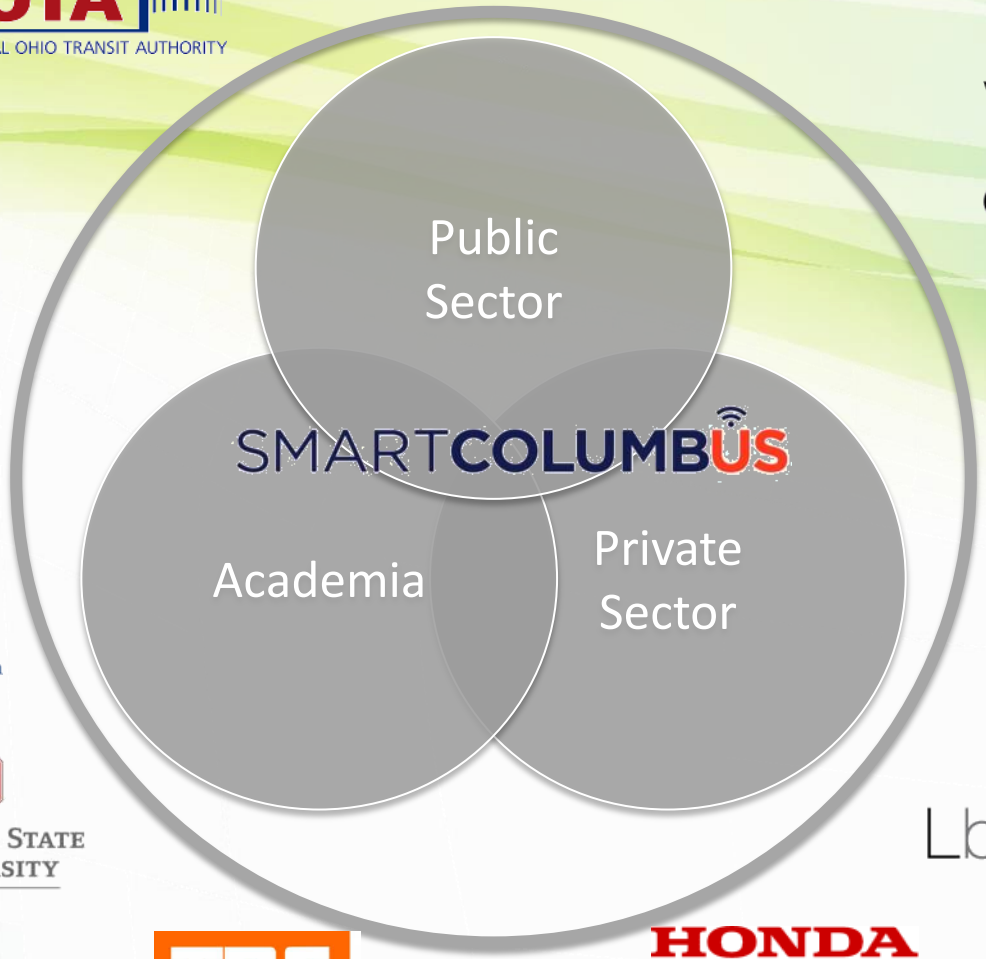
Why the Feds and Microsoft Co-Founder Paul Allen Are Betting on Columbus, OH

by Kirsten Korosec @kirstenkorosec JUNE 23, 2016, 6:19 PM EDT

THE WORLD IS WATCHING

Columbus earned 1.6 billion impressions via 1,022 media clips from around the world in June when the victory was announced.

The “Triple helix” knowledge-based economic development



THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR

Franklin County
Where Government Works

COTA
CENTRAL OHIO TRANSIT AUTHORITY

VULCAN
A Paul G. Allen Company

DEPARTMENT OF TRANSPORTATION
UNITED STATES OF AMERICA

COLUMBUS
PARTNERSHIP

gcac
Greater Columbus Arts Council

Nationwide®

Battelle
The Business of Innovation

AEP OHIO
An AEP Company
BOUNDLESS ENERGY™

THE OHIO STATE UNIVERSITY

Lbrands

TRC

HONDA
The Power of Dreams

AEP OHIO

Smarter infrastructure investments modernizing the grid

8-10 Micro-grids with Solar and battery storage

Advance Clean Energy R & D

Company Fleet Electrification

Energy Efficiency Programs

AMI Infrastructure – 528,000 meters

Electric Vehicle Supply Equipment (EVSE) – AEP Workplace plus

- **1000 Residential Chargers**
- **250 Level 2 Public Smart Chargers**
- **25 DC Fast Chargers**

Vehicle to Home Connectivity Research

Solar & Wind Deployment -- 900 MW goal

Smart Lighting - 200k locations

EVSE overview

Electric vehicle supply equipment (EVSE)

Home
(1,000)

Public Level-2
(250)

DC Fast Charger
(25)

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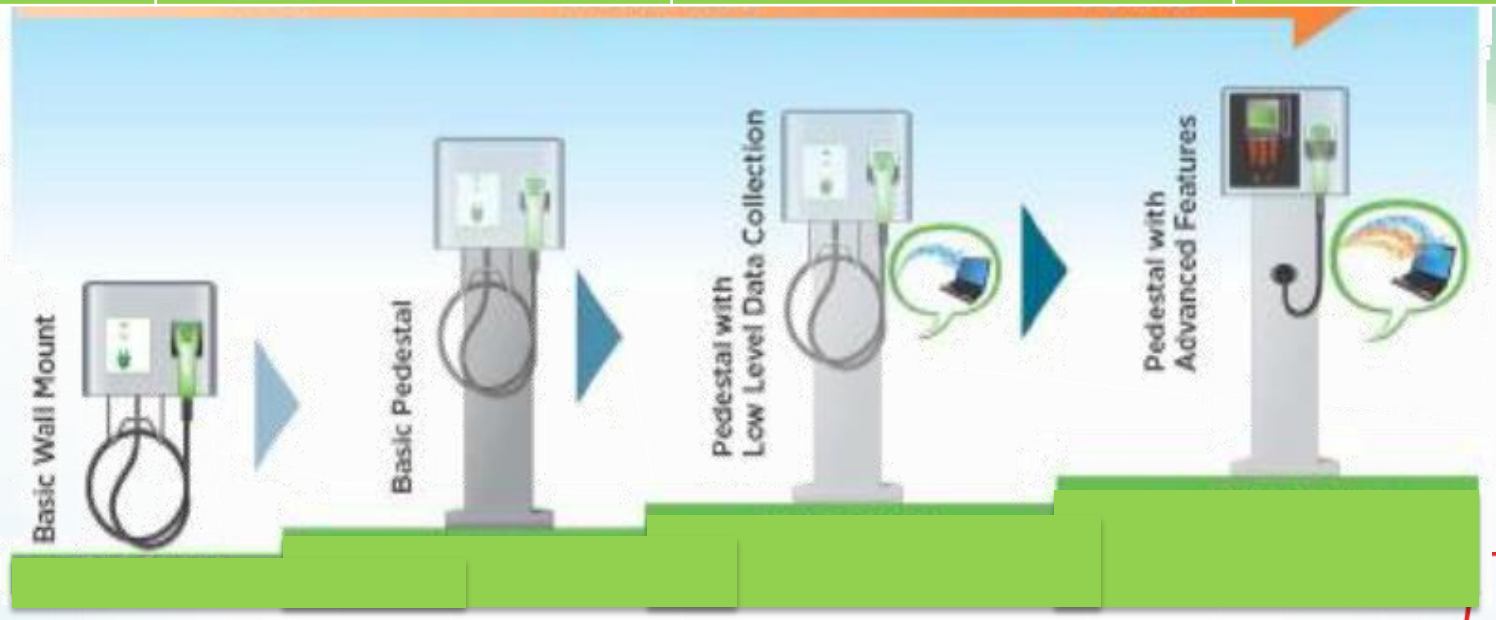
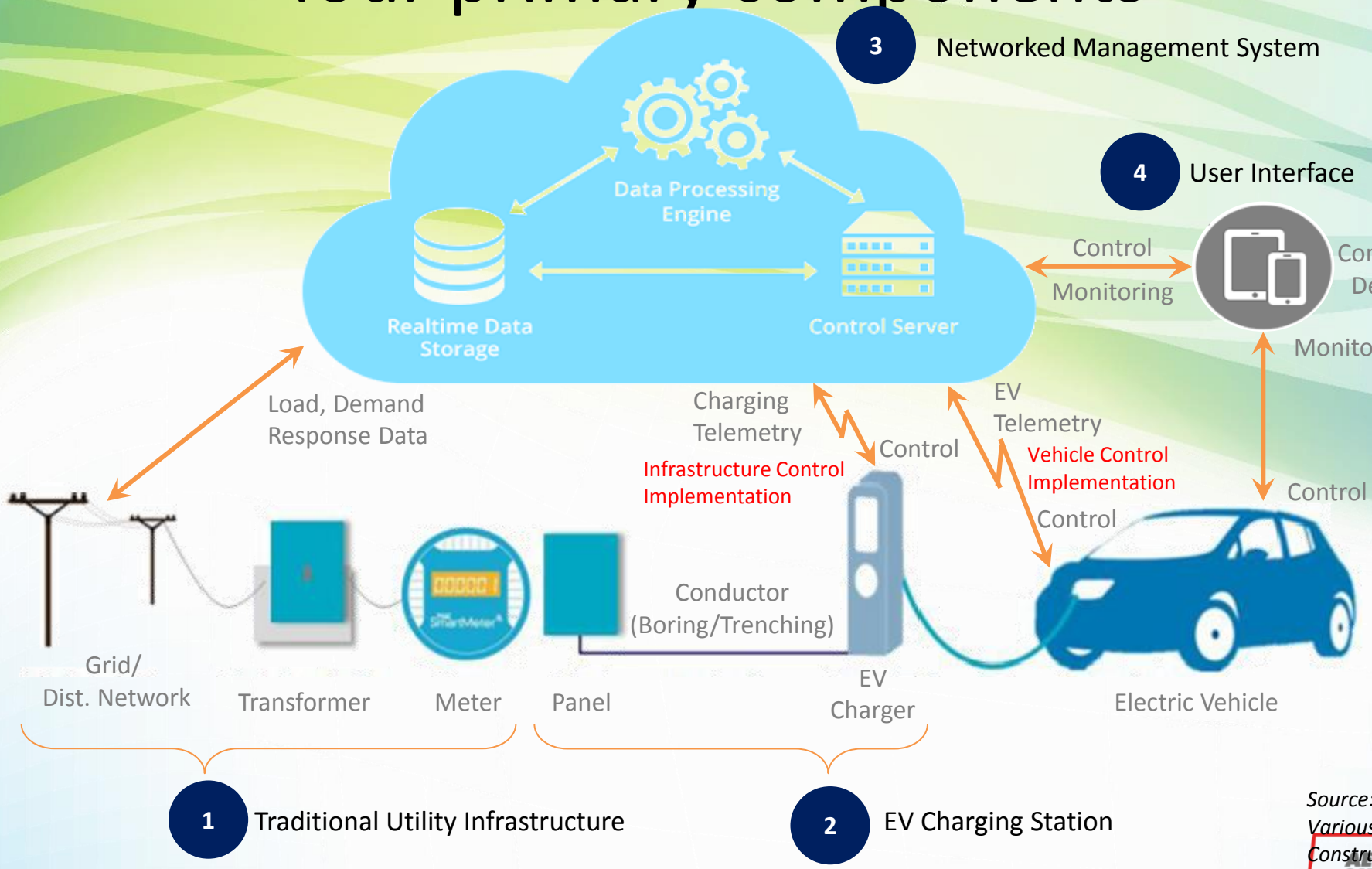
Supply Equipment Basics

Charging Level	Vehicle Range Added per Charging Time and Power	Supply Powers	Applicable Connector(s)
Level 1	4 mi/hour @1.4kW 6 mi/hour @1.9kW	120VAC/20A (12-16A continuous)	J1772 Tesla
Level 2	10 mi/hour @ 3.4kW 20 mi/hour @ 6.6kW 60 mi/hour @ 19.2 kW	208/240VAC/20-100A (16-80A continuous)	J1772 Tesla
DC Fast Charge	24mi/20 minutes @ 24kw 50mi/20 minutes @50kW 90mi/20 minutes @ 90kW	208/240VAC 3-phase (input current proportional to output power; ~20-400A AC)	Chademo CCS Combo Tesla Supercharger

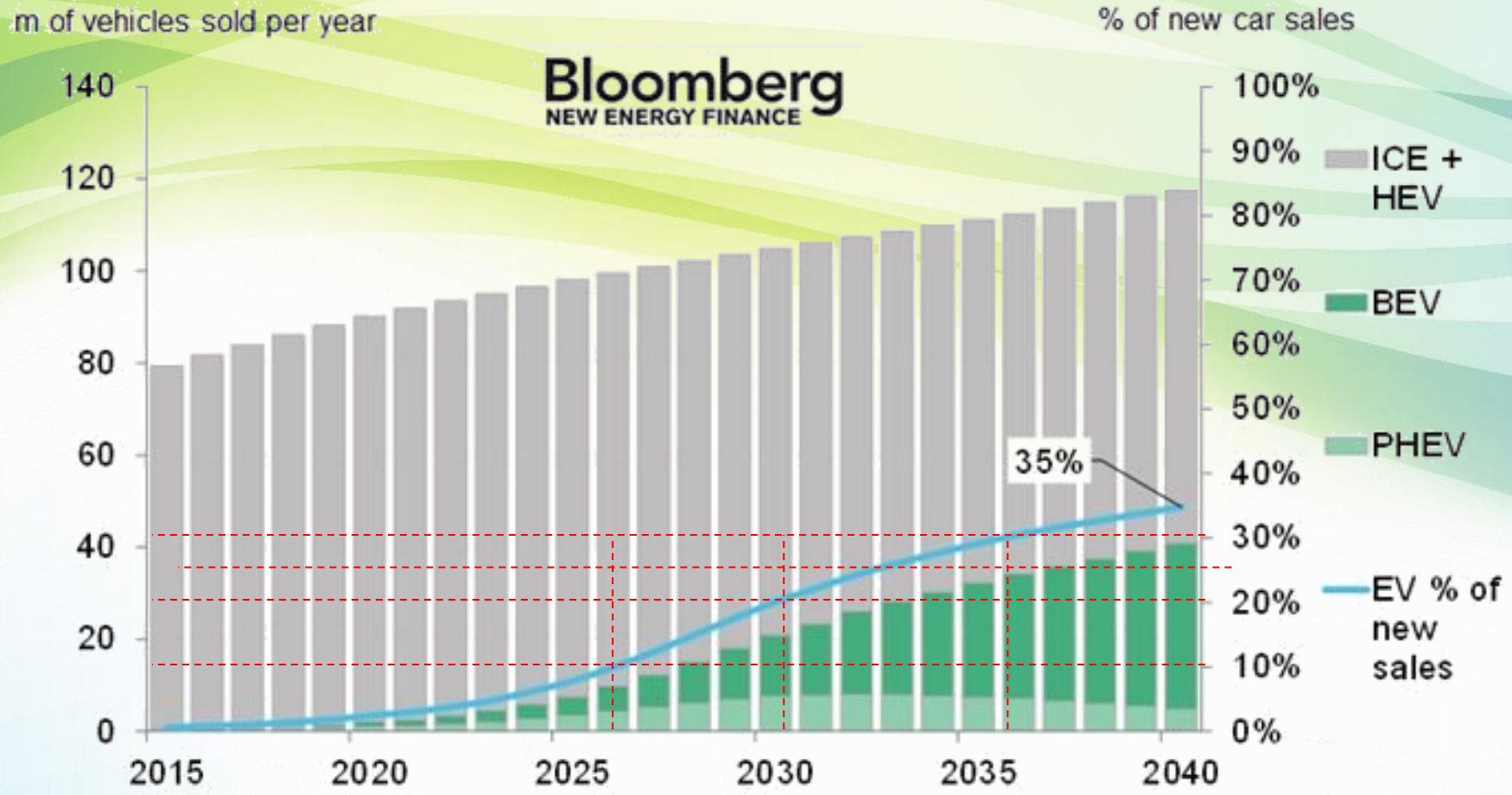


Public infrastructure overview four primary components



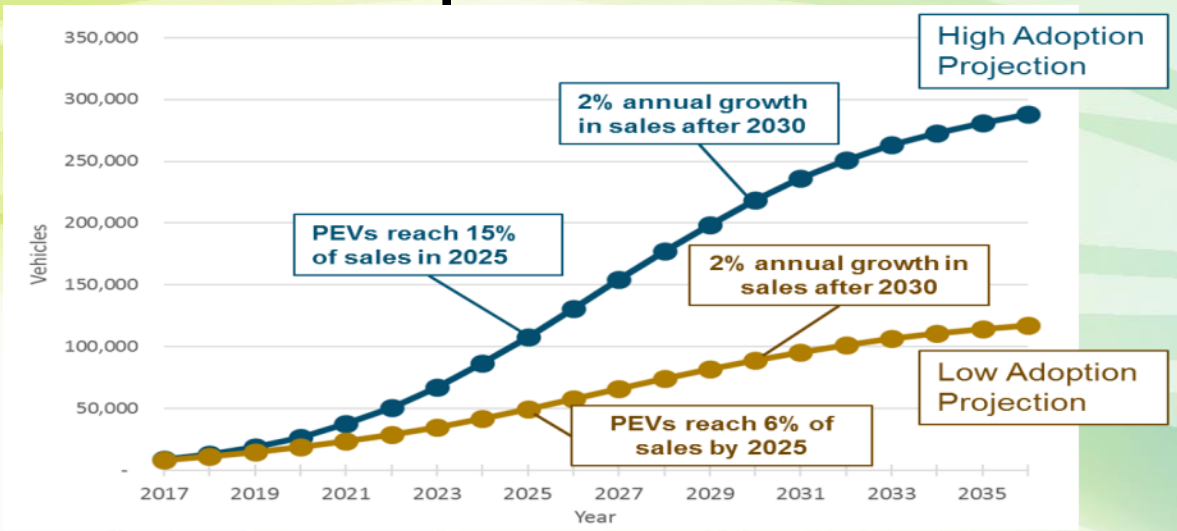
Source: Various / Constructed

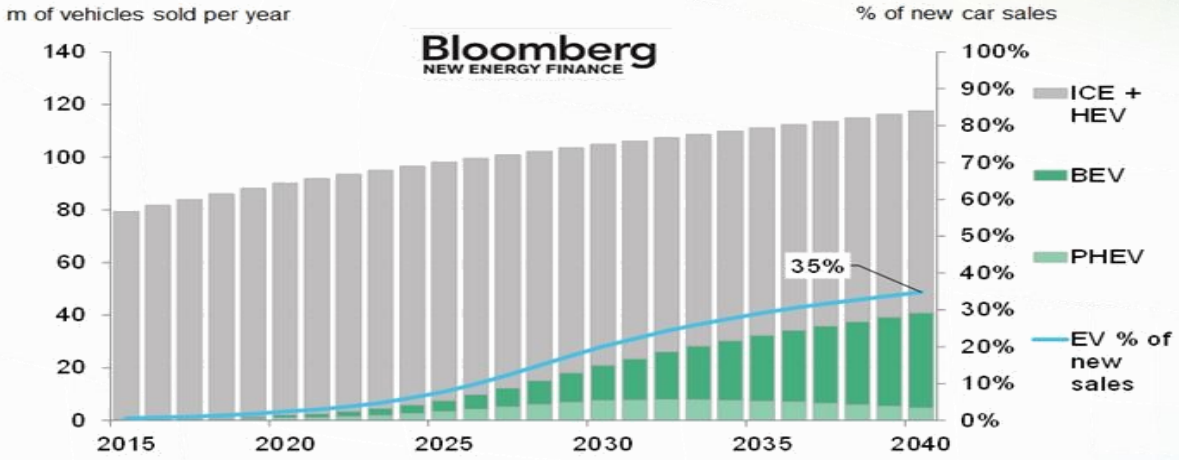
Market Adoption Assumptions



Source: https://about.bnef.com/blog/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/

Forecasted EV Adoption increasing adoption





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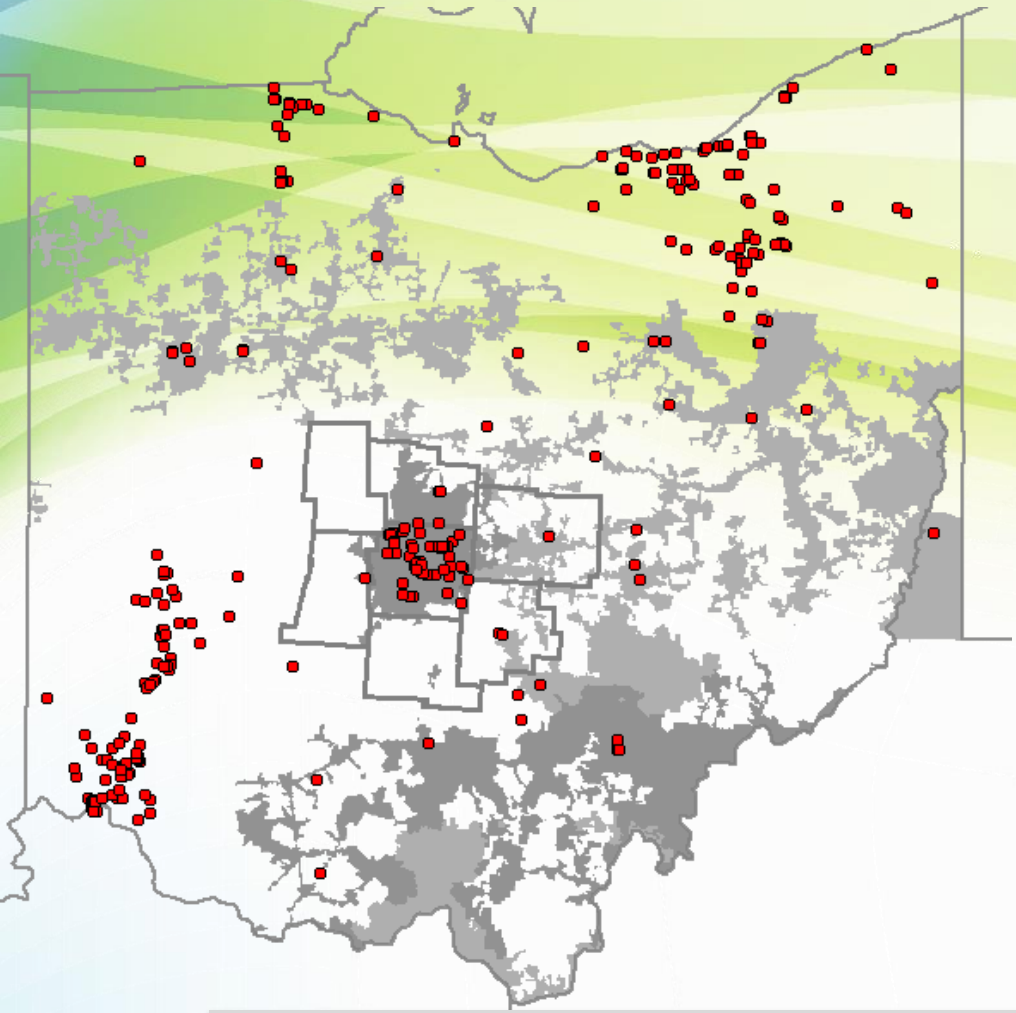
EVSE Infrastructure density



Deployed Infrastructure

- Ohio: 277
- AEP Ohio Territory: 222
- Smart Columbus: 156

Station Location Source:
http://www.afdc.energy.gov/locator/stations/

Existing infrastructure is inadequate to promote greater EV adoption

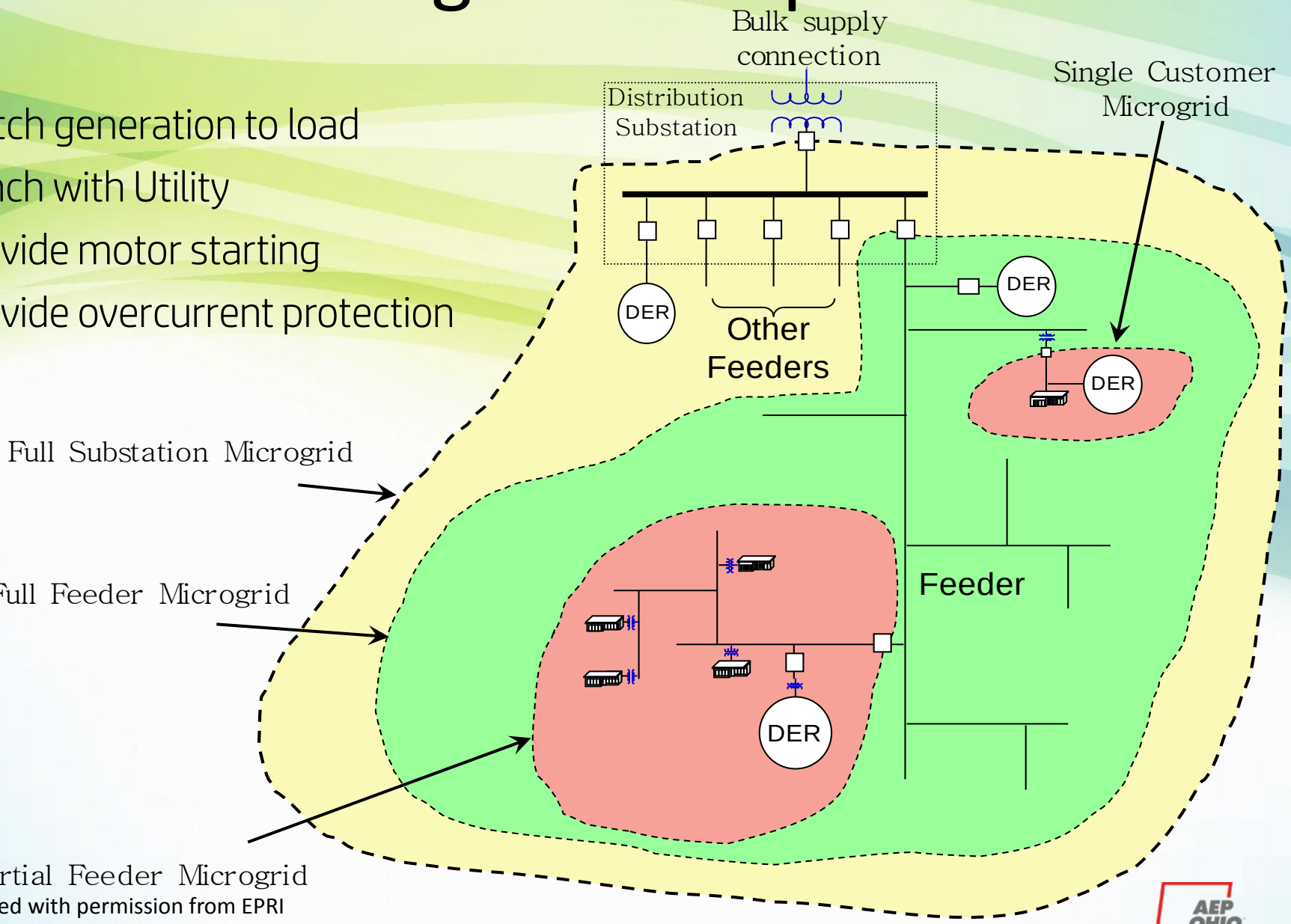
Why Utility Deployment Electric Vehicle Chargers?

- Utilities have a long planning horizon.
- Utilities have the ability to make capital expenditures.
- Utilities have the ability to manage demand.
- Utilities have considerable electric system expertise.
- Utilities are closely regulated.
- Utilities can extend PEV opportunities to disadvantaged segments.
- Utilities can identify best practices for charging station deployment.
- Utilities are uniquely positioned to choose appropriate charging locations.

Microgrid overview

Microgrid Examples

- Match generation to load
- Synch with Utility
- Provide motor starting
- Provide overcurrent protection



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Microgrids

Smart Switch

Distribution Line

Critical Facility (Fire Station)

Solar / PV

Battery Storage

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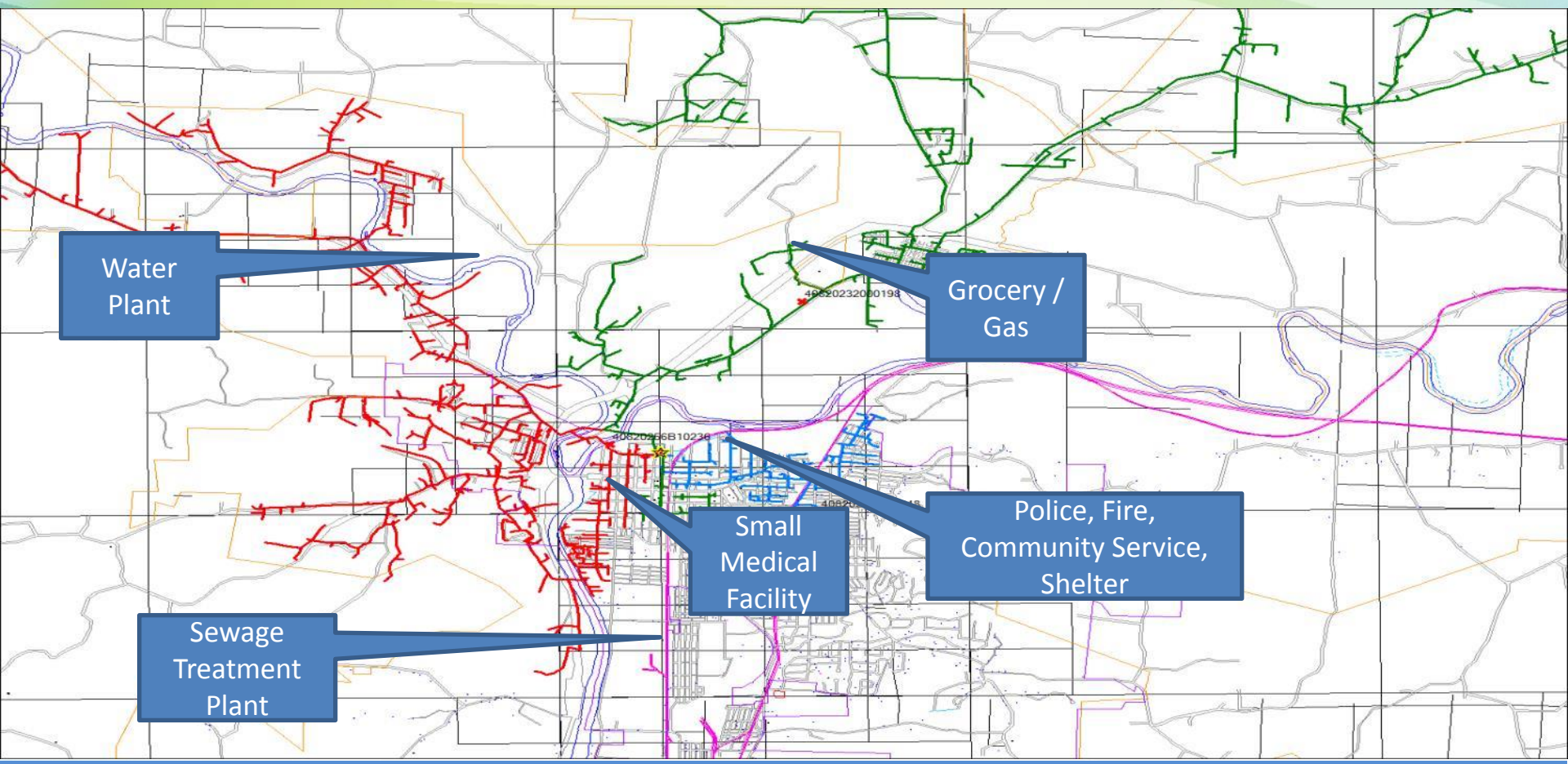
AEP Ohio Microgrid Benefits

- Improved resiliency and reliability for critical infrastructure and essential services
- Reduced system peak demand during load emergencies
- Integration of intermittent renewable generation facilitating clean energy and reduced emissions
- Ancillary services to the PJM market
- An AEP microgrid can facilitate the dispatch of energy storage system(s) to optimize the value of renewable energy when it is most needed

Typical Community Essential Services



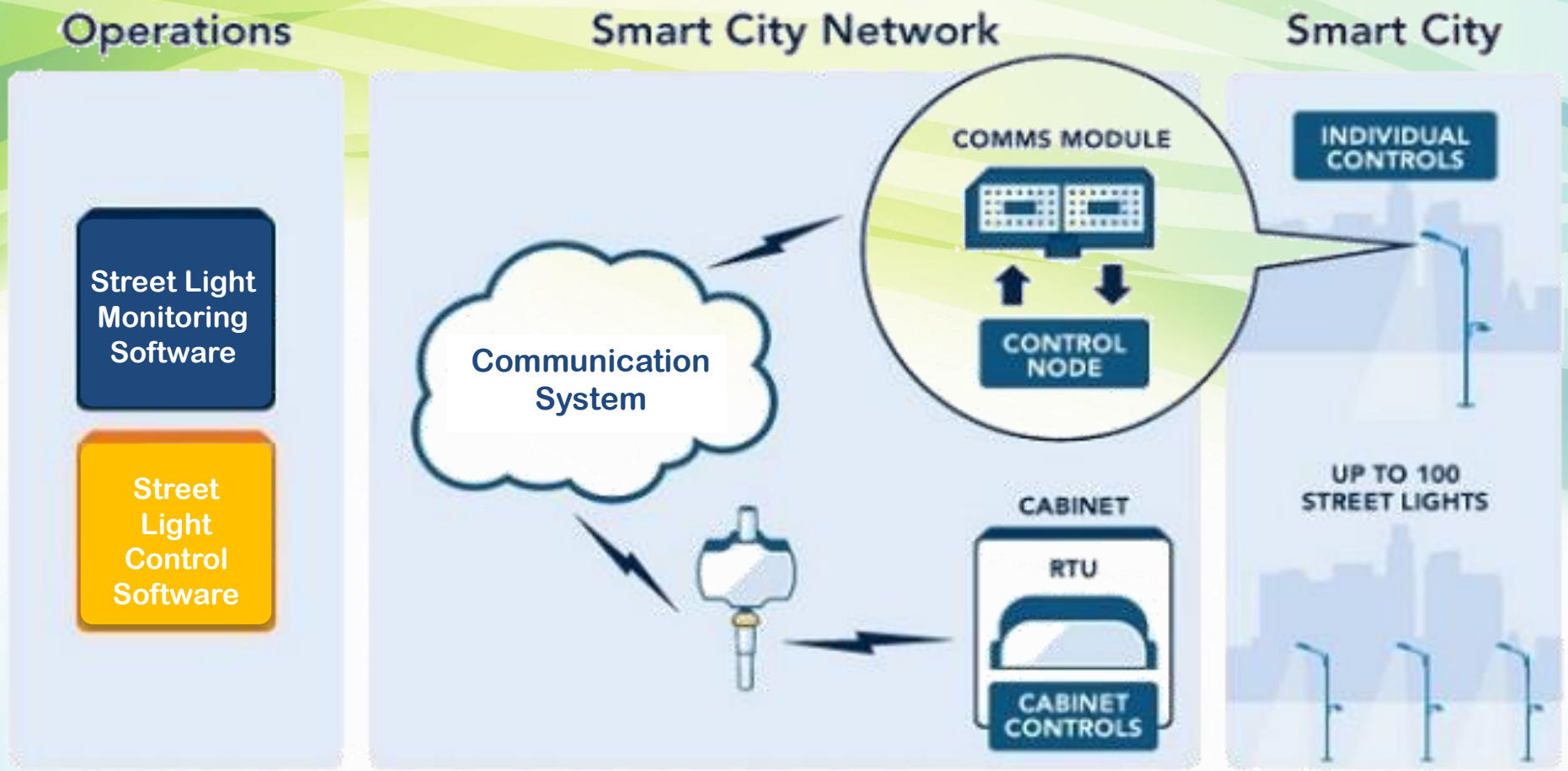
Powering essential services may require multiple microgrids coordinated by a common control system or new circuitry to connect the critical loads in a common microgrid.

Smart Street Lighting

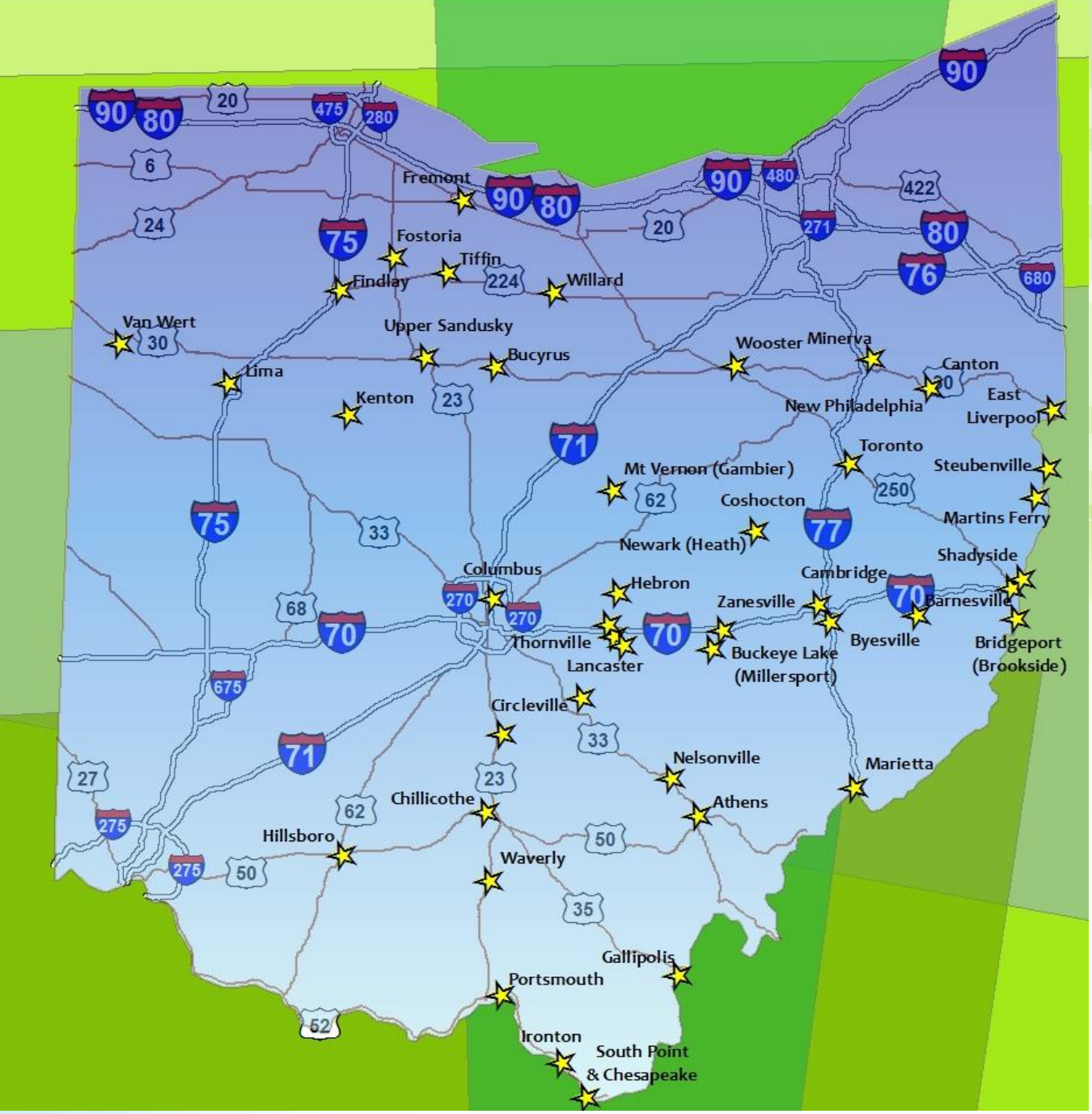
Smart Street Lighting

- Deploy appx. 202,000 Smart Street Lights

Smart Street lighting



Smart Street Lighting



- Deployed in the gridSMART Phase 1 & Phase 2 areas

Smart Street Lighting Benefits

- Improved safety and security through rapid light repair.
- Energy savings through repair of day burners.
- Operational savings and customer satisfaction through reduced call center volume.
- Additional operational savings through streamlined repairs.
- Potential for dimming and other advanced functionality.
- Faster response to lighting restoration requests.

Smart Street Lighting Use Cases

- Public Safety, gun shot detection
- Transportation – Parking spot availability
- Economic Development – Car and Pedestrian Counts
- Environmental - Smog detection
- Nature – Sea Turtles

From designboom.com

Questions?