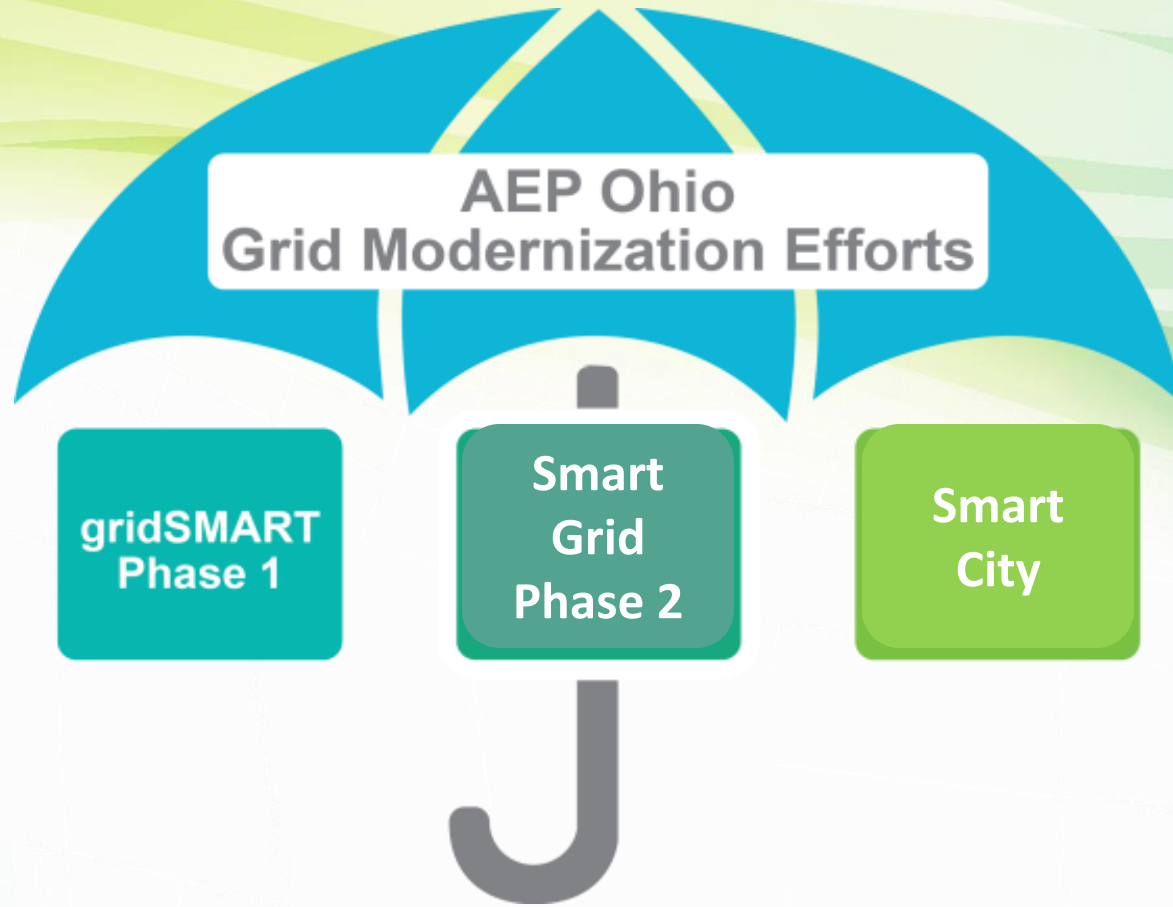


The background of the slide features a photograph of a city skyline at dusk or dawn, with several skyscrapers illuminated against a cloudy sky. In the foreground, a river flows through a park-like area with green grass and a paved path. The title text is overlaid on the image in a large, white, sans-serif font.

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

Scott Osterholt
Director, Grid Modernization
UEDA Summer Forum
Tuesday July 24, 2017

AEP Ohio's Grid Modernization Plan



gridSMART Phase 1 Technologies



AMI Meters –
132k Deployed



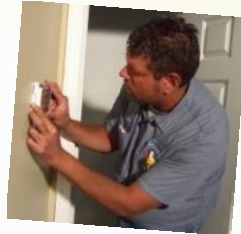
Volt Var Optimization – 17 circuits



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.

Benefit / Cost Analysis

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

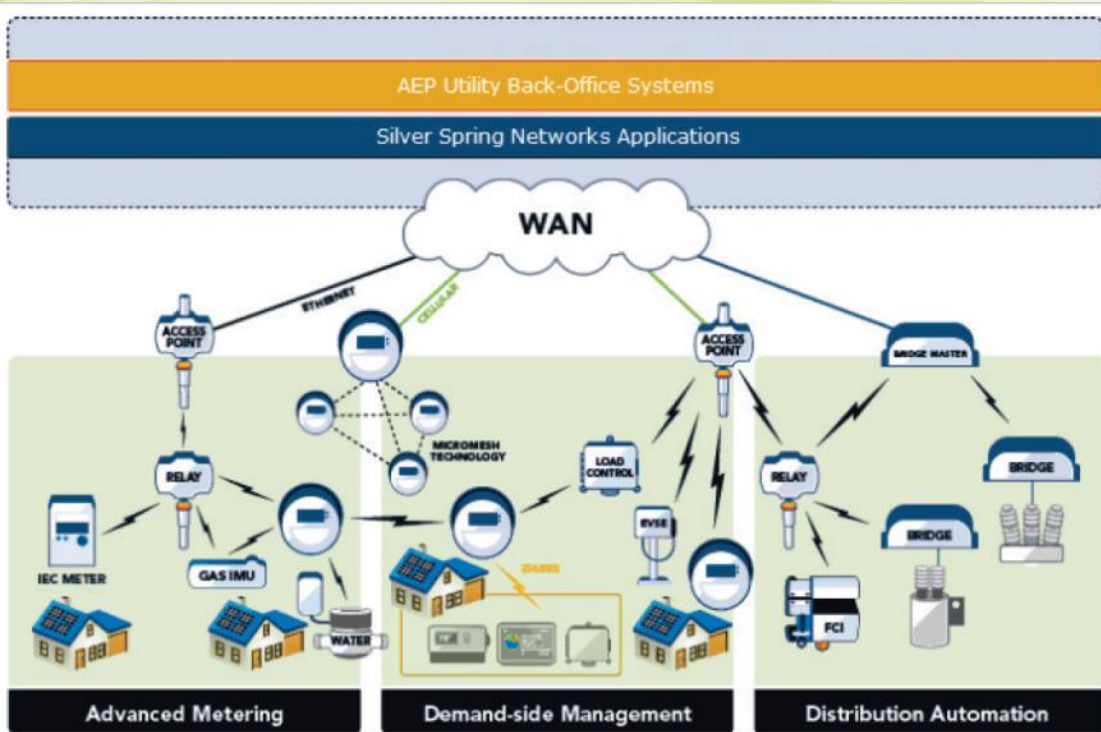
gridSMART Phase 2 Environmental Benefit Expectations

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



Customers are the Focus



YOUR NEW SMART METER: NOT JUST A PRETTY FACE

We know, it's just a meter. But, to our eyes, it's pretty. And, we think you'll see the beauty in it too.

Your new smart meter helps with power outage restoration by improving response times and speeding repairs. We don't have to access your property to read it, and it simplifies the billing process by eliminating estimated bills.

It also enables new features like the ITS YOUR POWER™ app, which will give you the power to manage and control your energy usage from your smartphone. You'll also be able to view your usage from the "My Account" page at AEPOhio.com.

In short, your new meter matters a lot. It will help save you money—without sacrificing your comfort.

We'll be coming to your neighborhood in the next few weeks to begin smart meter installation. It's a simple process of upgrading to a new meter, with a brief power disruption of only a few minutes. You don't even need to be available when we do it.

[We hope you'll agree that as technologies go, it's truly a beautiful thing]

For more information about smart meters, visit our website at AEPOhio.com/SmartMeter or call toll free 1-866-872-6446.



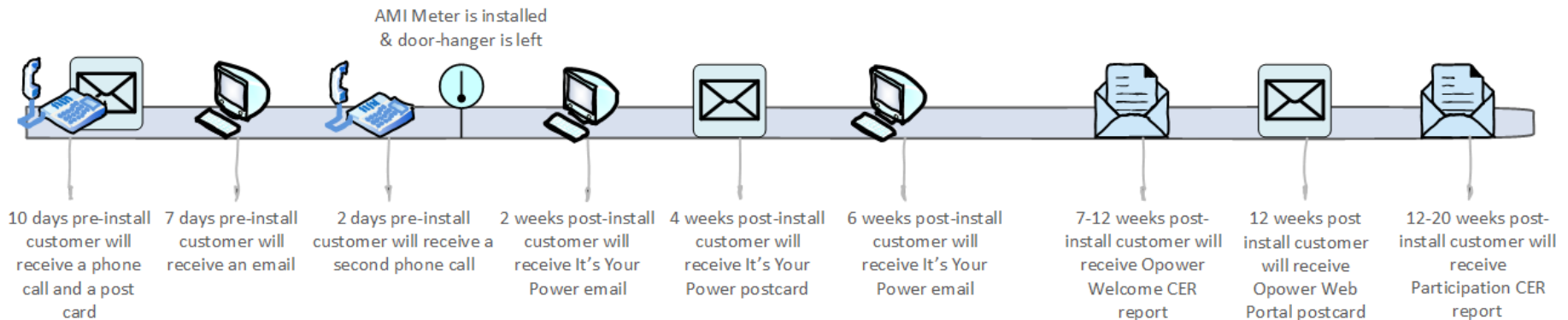
AEP Ohio Customer Communications

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



New Customer Timeline of Touchpoints



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[®]



Home My Energy Use My Rates My Plan Ways to Save

My usage details What uses most Compare my bills

My Energy Use
Fuel type: electricity

Sun, Jul 9, 2017
Similar homes comparison

Select view: by day

3.65 kWh

Similar homes comparisons are available [by year](#) only.

2.74

1.83

0.91

0

12 am 6 am noon 6 pm 11 pm

Similar homes Usage Costs

- You
- All similar homes
- Efficient similar homes

[What homes are compared?](#)

Find tips to reduce your use:

- [Free steps to take](#)
- [Smart purchases](#)
- [Great investments](#)

Note: The amounts shown here are usage charges only. They do not include taxes or fees, so they may not match your total billed amounts each month.

Green Button Download My Data



High Bill Alerts (AMI)

AEP branding

Ability to model and display cost information associated with usage

AEP OHIO
ELIZABETH GLAUB
Acct # *****3-7

Your electricity bill is projected to be
\$135.97

⚠ That's \$37.43 more than the same time last year.

You used the most electricity in the evening

	Mornings	6am - 12pm	24%
	Afternoons	12pm - 6pm	25%
	Evenings	6pm - 12am	27%
	Nights	12am - 6am	24%

Based on your electricity use between February 2, 2016 - February 15, 2016

[Log in to learn more about your energy use.](#)
ANALYZE YOUR USE

[Unsubscribe from these emails](#)
[Manage preferences](#)

AEP Ohio - Home Energy Reports
850 Tech Center Dr, Gahanna, OH 43230-6605
AEPOhioReports@AEP.com

Copyright 2013-2016 Opower. All rights reserved.
Actual bill will vary based on usage, taxes, and fees.

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

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

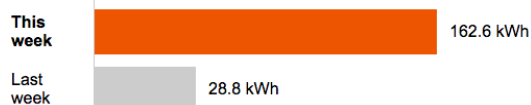
Messaging is consistent and synchronized across channels for a seamless customer experience

Weekly AMI Insights (Opt In)



Jane Doe
Acct #
*****00e1
Sep 2-9

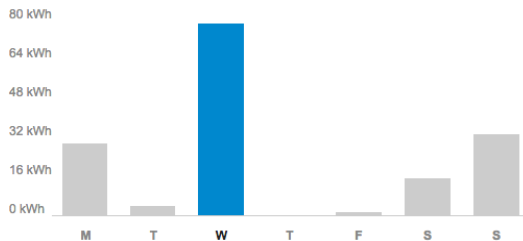
! You used 465% more electricity this week.



Your projected electricity bill: **\$5.04***
With about 14 days left. **This is not a bill.**

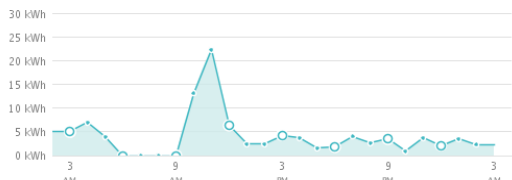
A day by day breakdown

You used the most on Wednesday, Sep 4. [See more](#)



A closer look at your highest day

Wednesday, Sep 4 [See more details](#)



Personalized Tips

Unplug electronics when they're not in use

Many electronic devices and kitchen appliances use power even when they're turned off. To save energy, unplug them from the wall when you're not using them.

Save up to \$50 per year

Buy ENERGY STAR® appliances

ENERGY STAR certified products use as much as 65% less energy than standard models. The ENERGY STAR label can be found on a variety of products for your home.

Save up to \$680 per year, varies by item

Replace your inefficient light bulbs

Inefficient incandescent bulbs are costly to run and replace in the long term. Use compact fluorescent light (CFL) bulbs — they use 75% less energy and last at least ten times longer.

Save up to \$45 over bulb life

[Make my tips more personalized](#)

[See more tips](#)

* Cost and energy projections are estimates only, not an assurance of what your actual bill will be. Your actual bill may vary due to factors like your actual usage, taxes, and fees.

[Manage Preferences](#) | [Unsubscribe](#) from these emails
AEP Ohio - Home Energy Reports, 850 Tech Center Dr, Gahanna, OH 43230-6605
Copyright 2013-2015 Opower. All rights reserved.

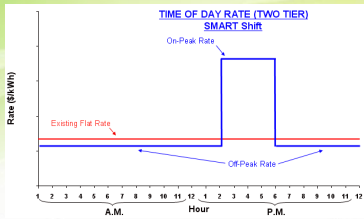
Support customer satisfaction to let customers know when they are trending towards a high bill and how they can adjust their energy use before the end of the billing period, reducing bill shock and associated calls into the call center.

Provide enhanced customer care functionality to all active AEPO AMI customers

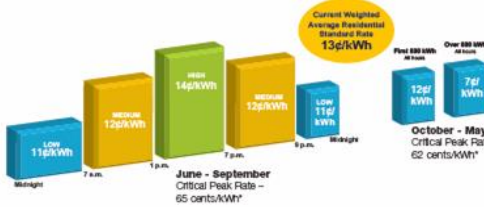
Smart Grid Programs & Tariffs

Tariffs

SMART ShiftSM – 2-tier TOD



SMART Shift PlusSM – CPP



SMART ChoiceSM RTP-da



Programs

SMART CoolingSM – Programmable Communication Thermostat



SMART Cooling PlusSM – Load Control Switches (LCSs)



eVIEWSM – in Home Displays (IHDs)



It's Your Power App



Get Your Free Tools Now—And Save For Years To Come

IT'S YOUR POWER.

The free *IT'S YOUR POWER*SM app and AEP Ohio Energy Bridge can help lower your electric bills.

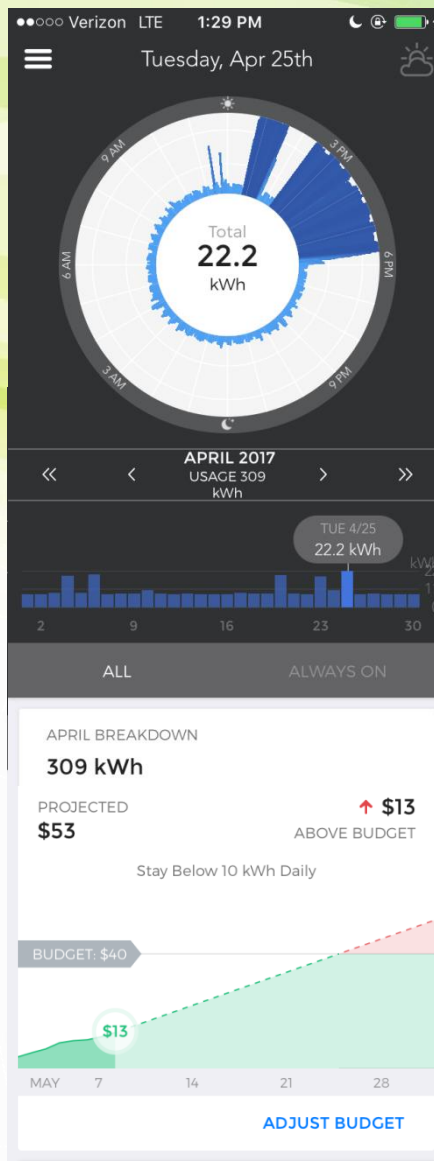
Thousands of your neighbors are saving on their electric bills with this powerful combination of free tools that lets you see your electrical usage almost instantly.

Download the free *IT'S YOUR POWER* app to your smart phone to take advantage of the FREE Energy Bridge (a \$100 value) offer available for a limited time. Together, you'll have the information you need to make money-saving choices about your electricity usage.

[CLICK HERE](#) for download and other information.

IT'S YOUR POWER app features

- Easy-to-use, smart phone navigation
- Energy Clock allows you to pinpoint when you're using electricity throughout the day and what influences your usage. When paired with the free Energy Bridge, you can see your usage in near real-time.
- Budget targets (kWh or \$) to help manage your electricity usage
- Notifications and alerts about energy usage
- Tips on how to optimize your energy usage
- Remote control of your heating and cooling with the *IT'S YOUR POWER* communicating thermostat
- Convenient control of other smart devices



Smart Grid Mobile



Smart Grid Phase 2 Customer Engagement

QUICK TURN DISPLAY

20'x10' Tented Display – Mid-July Launch



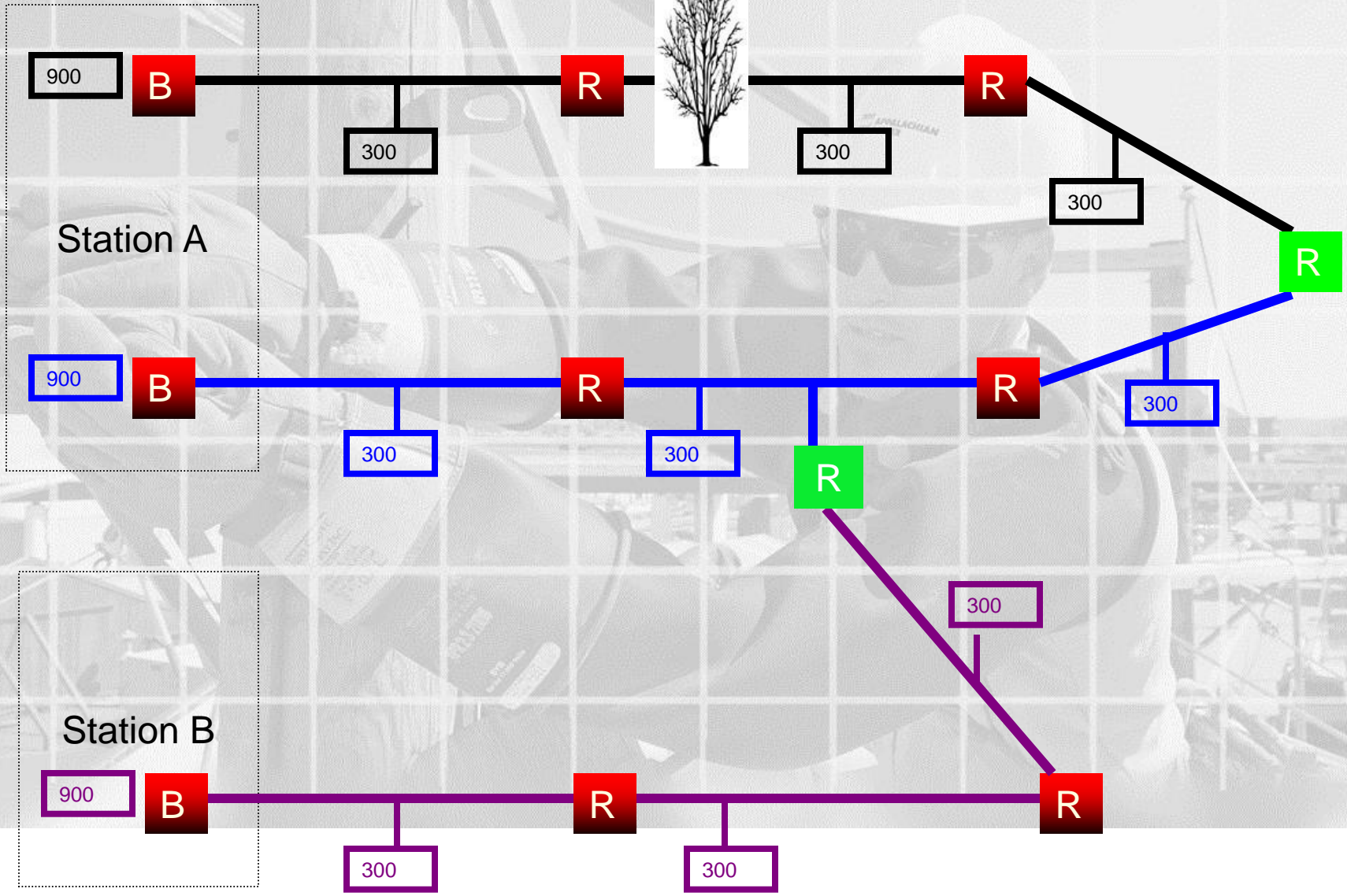
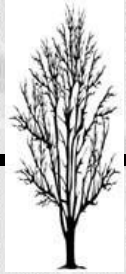
Distribution Automation Circuit Reconfiguration (DACR)



- 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



Station A

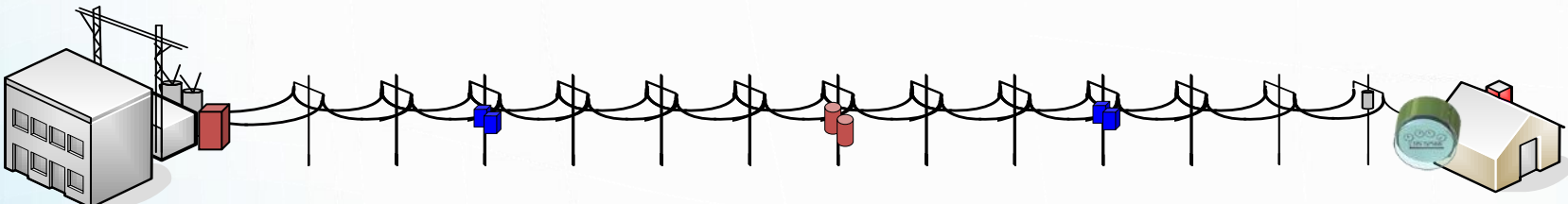
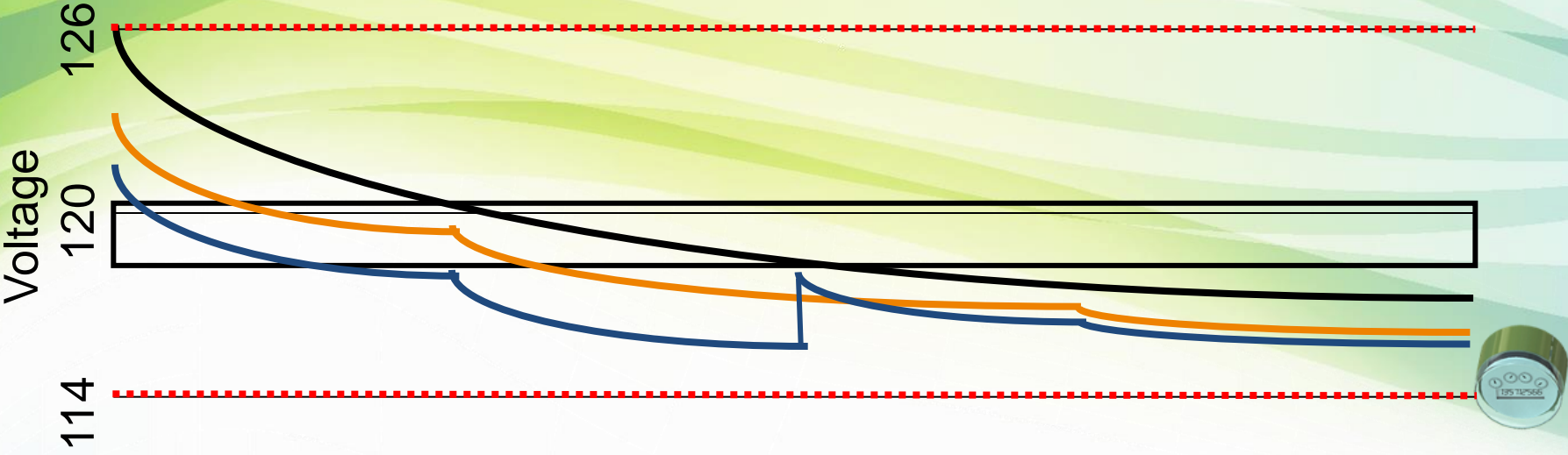
Station B

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%



Volt VAR Optimization



Distance from Substation



An **AEP** Company

BOUNDLESS ENERGY™

A panoramic view of the Columbus, Ohio skyline at dusk. The sky is a deep blue with scattered white clouds. The city lights are on, and the buildings are reflected in the water of the Scioto River in the foreground. The Ohio Statehouse is prominent on the right, illuminated with red and white lights. Other buildings of varying heights and architectural styles are visible across the skyline.

SMART IS JUST THE START:

AEP Ohio's Smart City Overview

June 2, 2017

Columbus, OH

What is the Smart City Challenge?



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

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

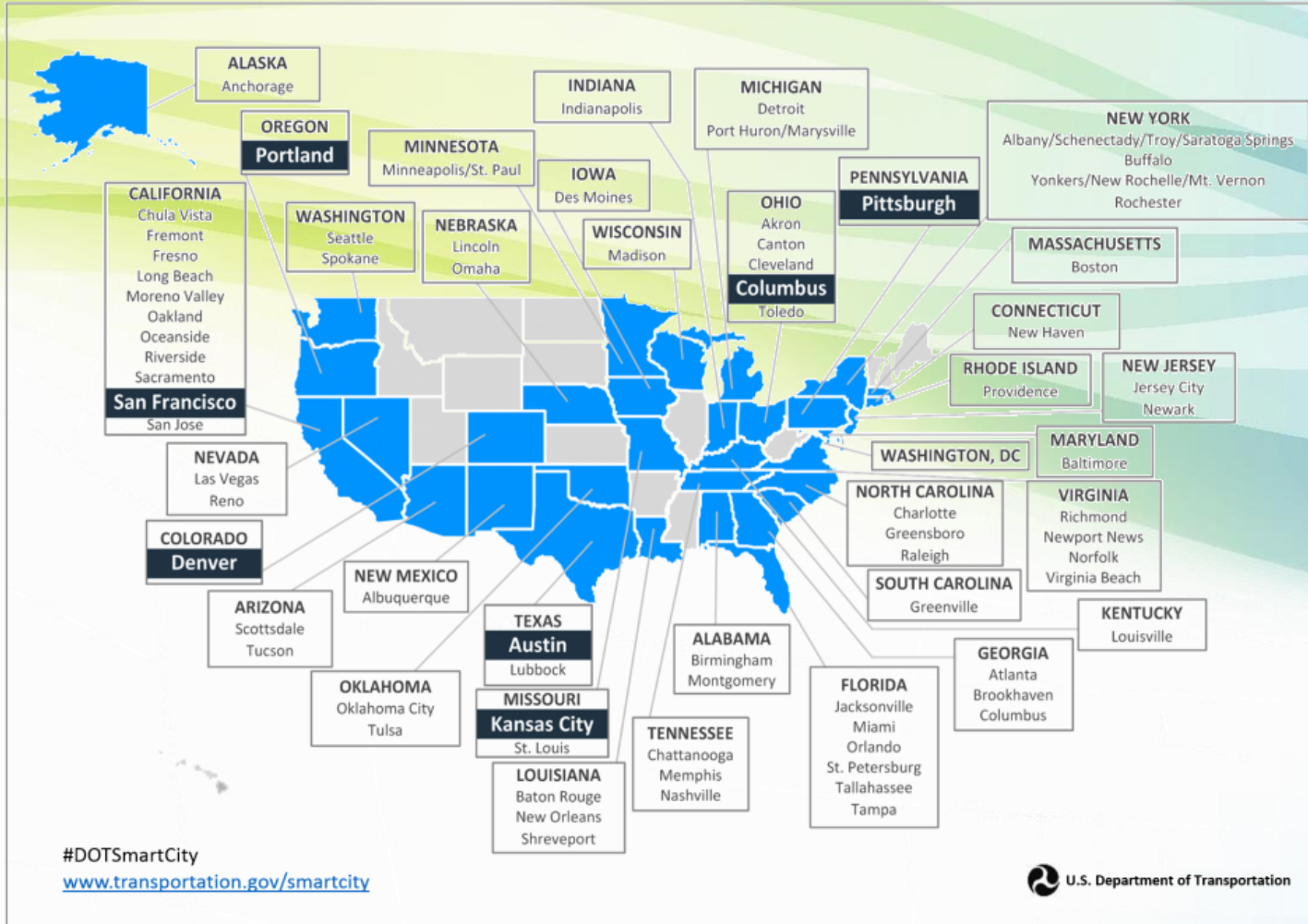
applications
received for the Smart City
Challenge

7

Smart City
Challenge Finalists announced in
March at SXSW

1

Smart City
Challenge Winner announced in June



#DOTSmartCity
www.transportation.gov/smartcity

U.S. Department of Transportation



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



\$40 M

1 WINNER



\$10 M

A Paul G. Allen Company

COLUMBUS \$90 M

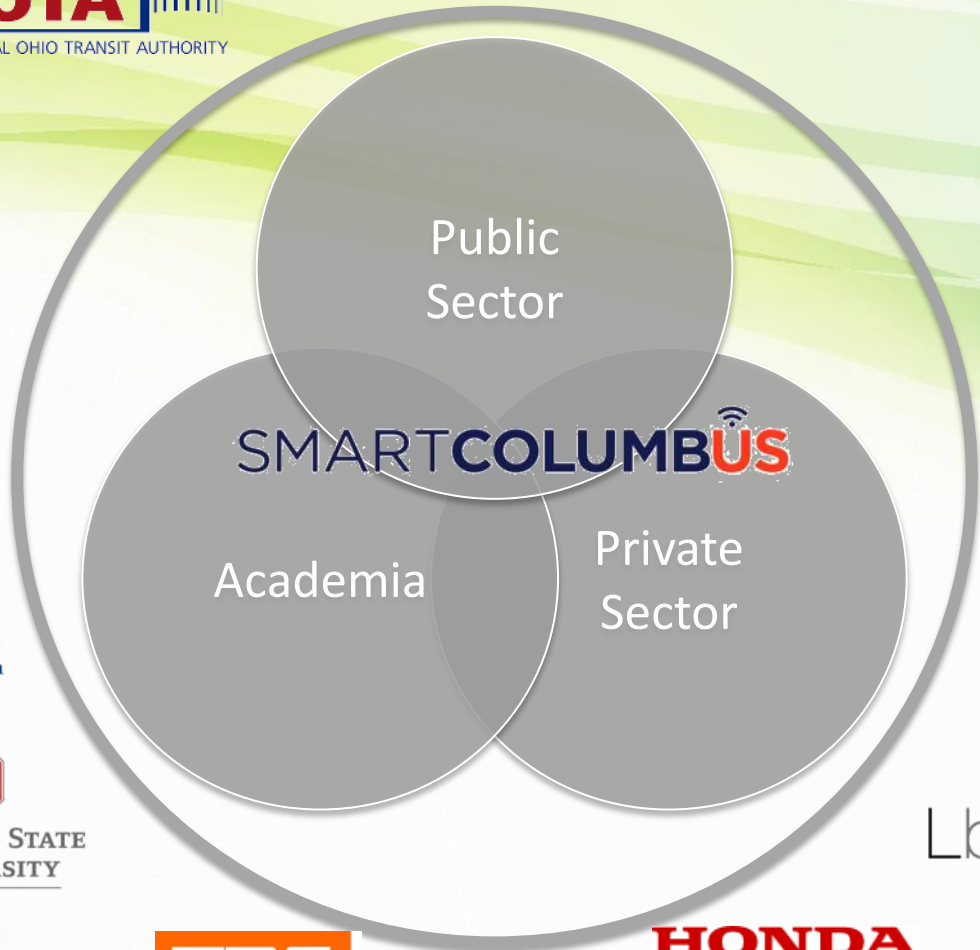
TOTAL \$140 M

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



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



COLUMBUS
PARTNERSHIP

gcac
Greater Columbus
Arts Council

N
Nationwide®

Battelle
The Business of Innovation

AEP OHIO
An AEP Company
BOUNDLESS ENERGY™

O
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

An aerial photograph of a city skyline at dusk. The sky is a mix of blue and orange, with clouds. The city buildings are illuminated, and their lights reflect on a river in the foreground. The river flows from the bottom left towards the right. In the foreground, there are green spaces and a paved path.

EVSE overview

Electric vehicle supply equipment (EVSE)



Home
(1,000)



Public Level-2
(250)



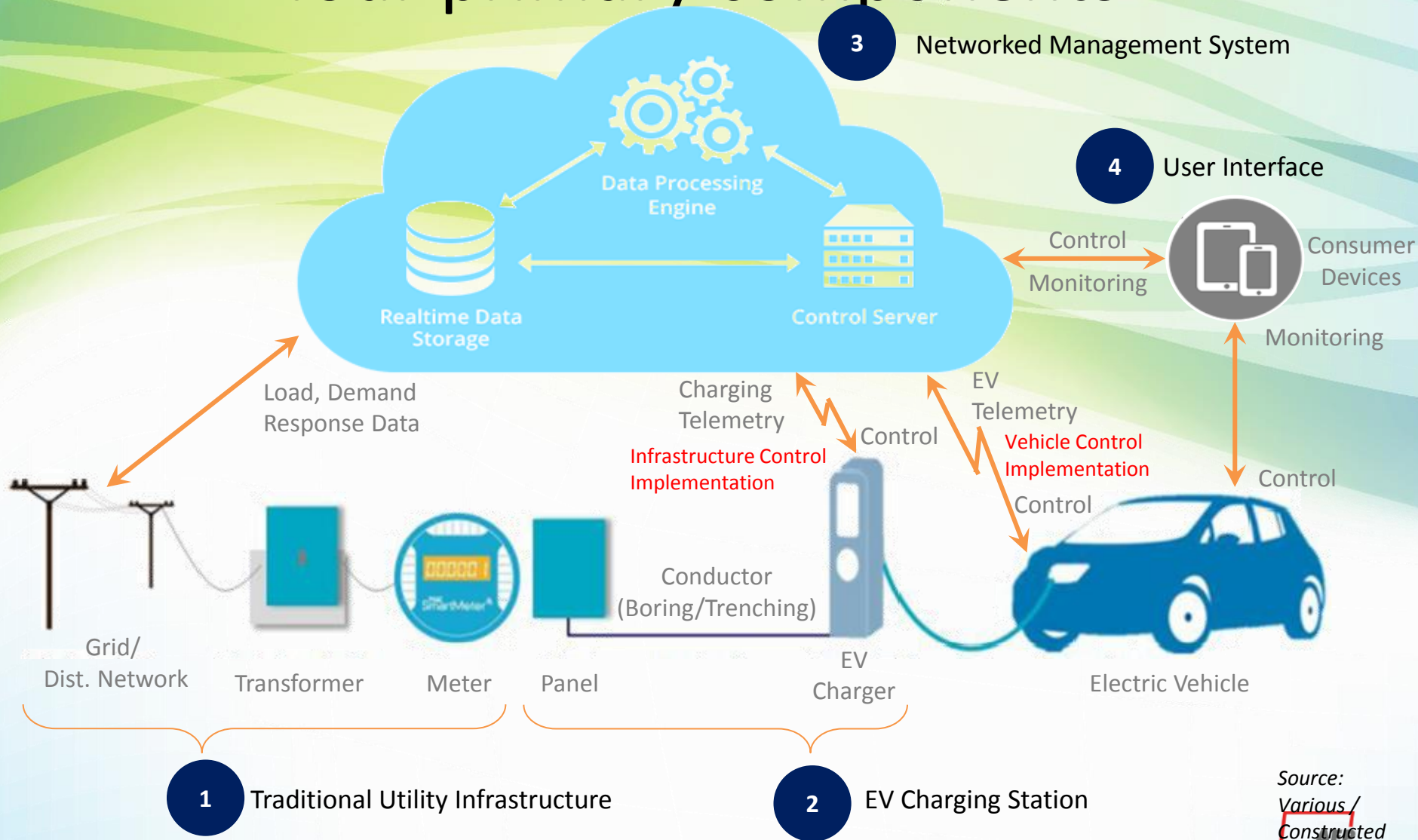
DC Fast Charger
(25)

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



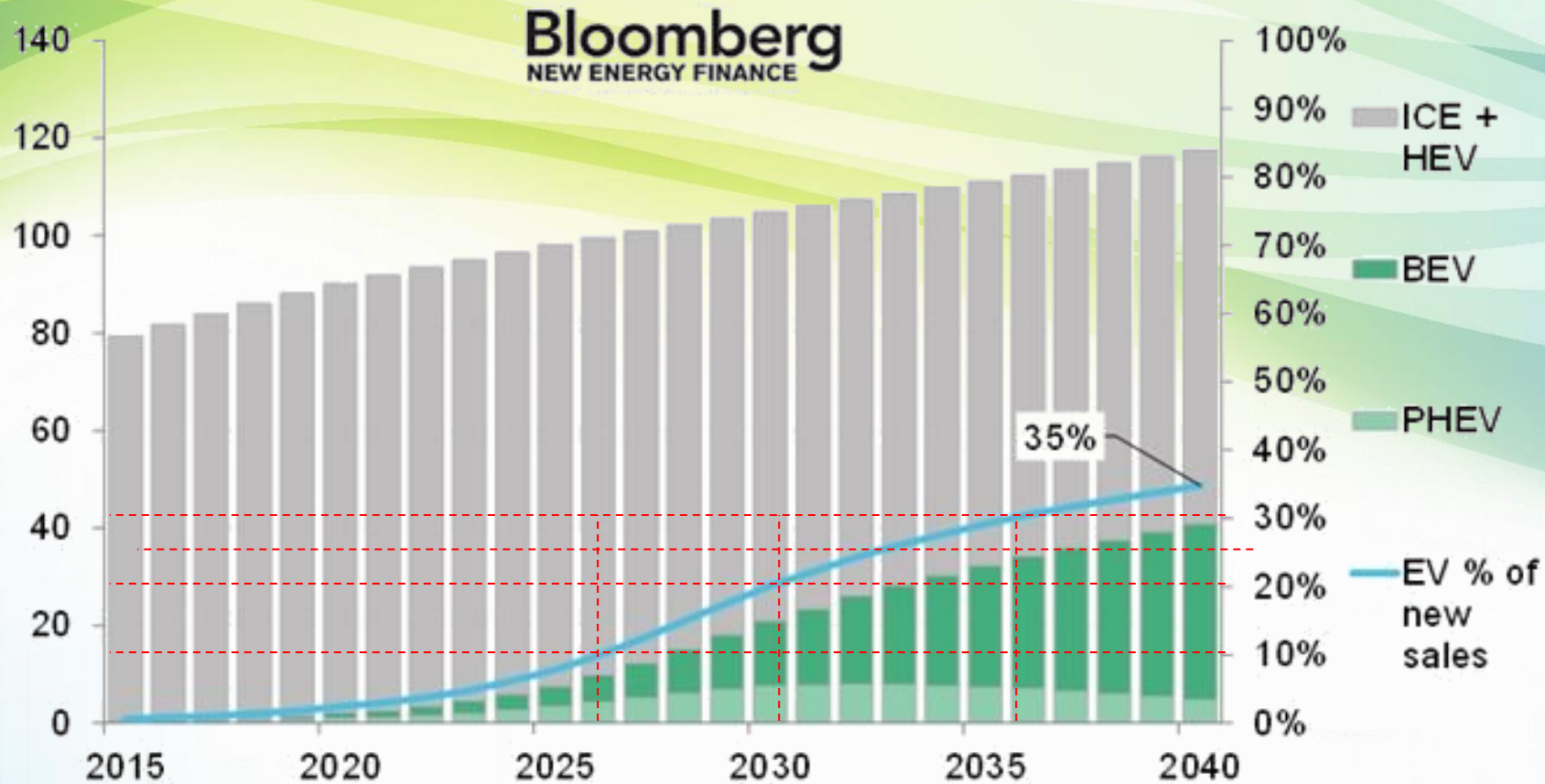
Public infrastructure overview four primary components



Market Adoption Assumptions

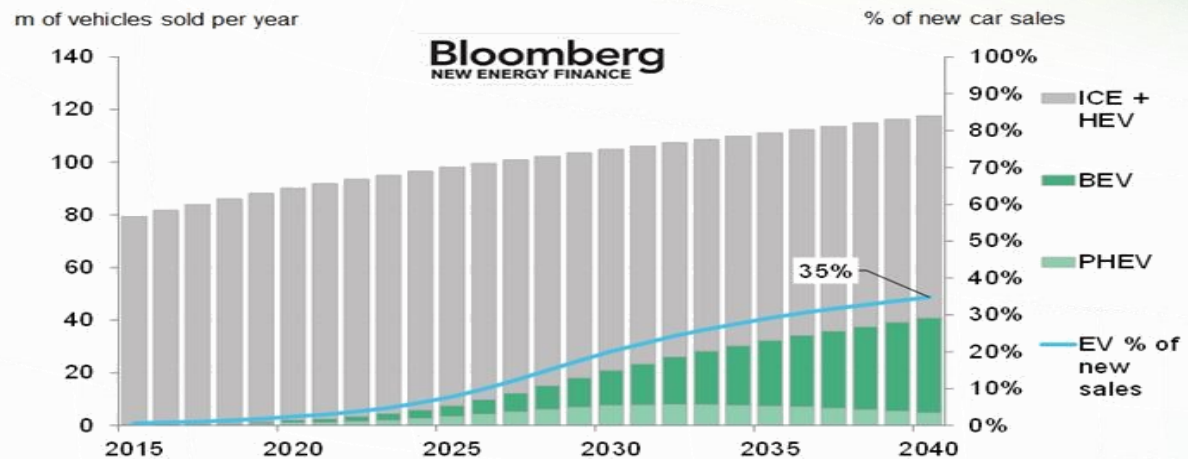
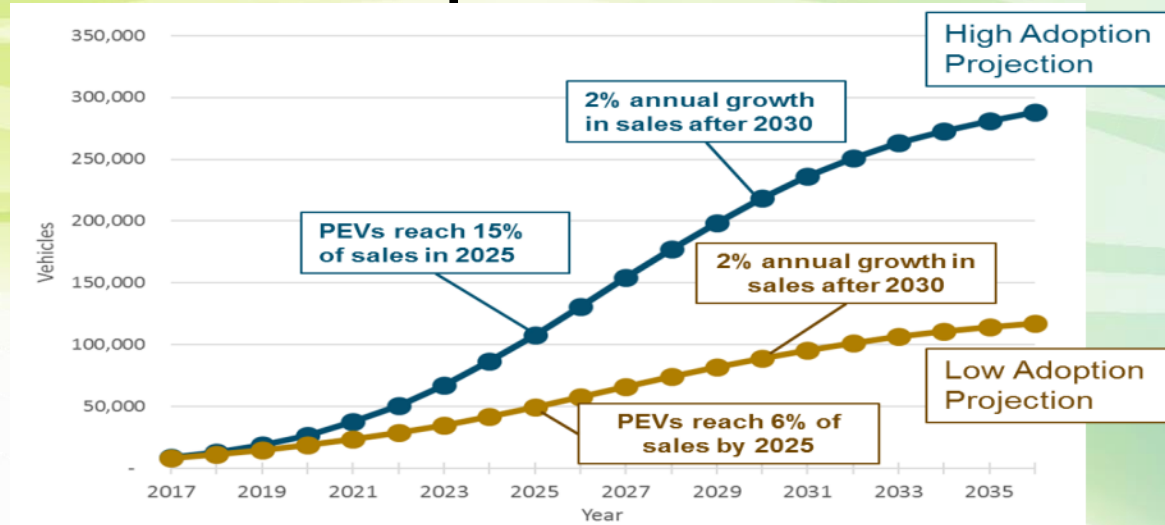
m. of vehicles sold per year

% of new car sales



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

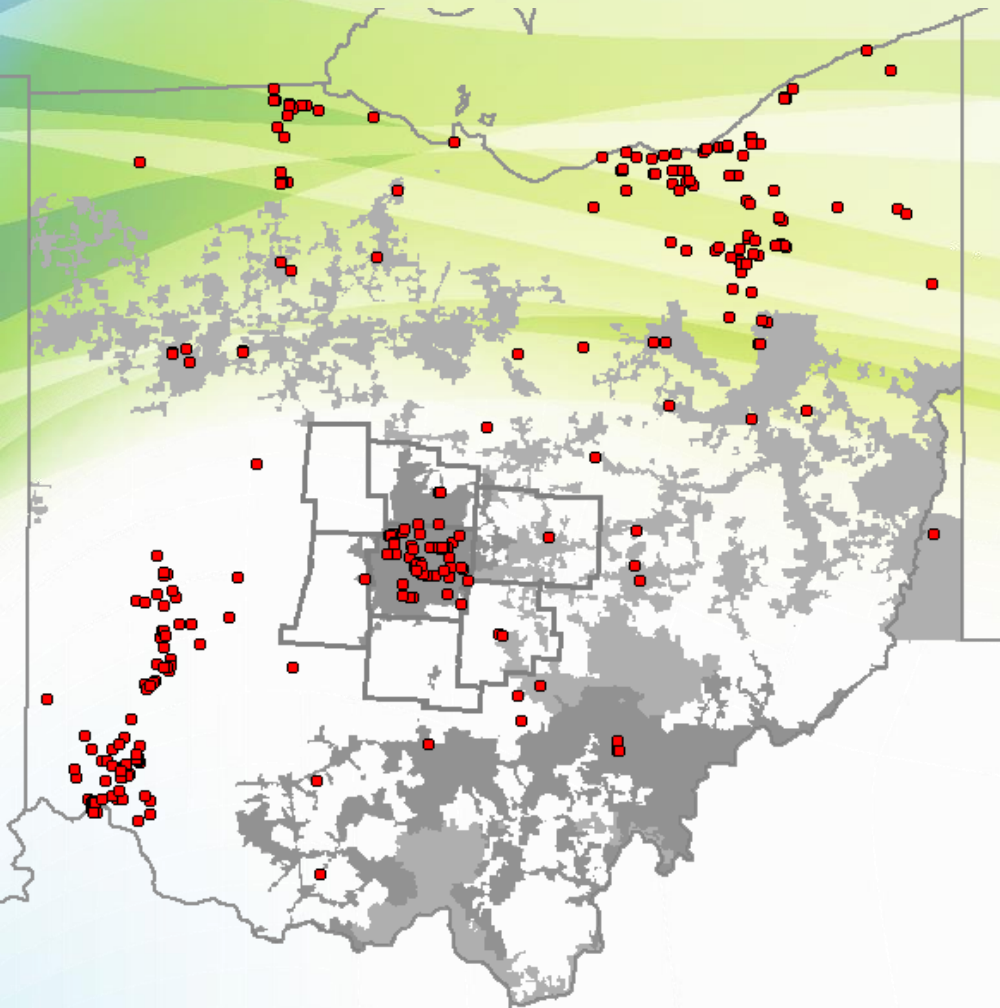
Forecasted EV Adoption increasing adoption



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



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.

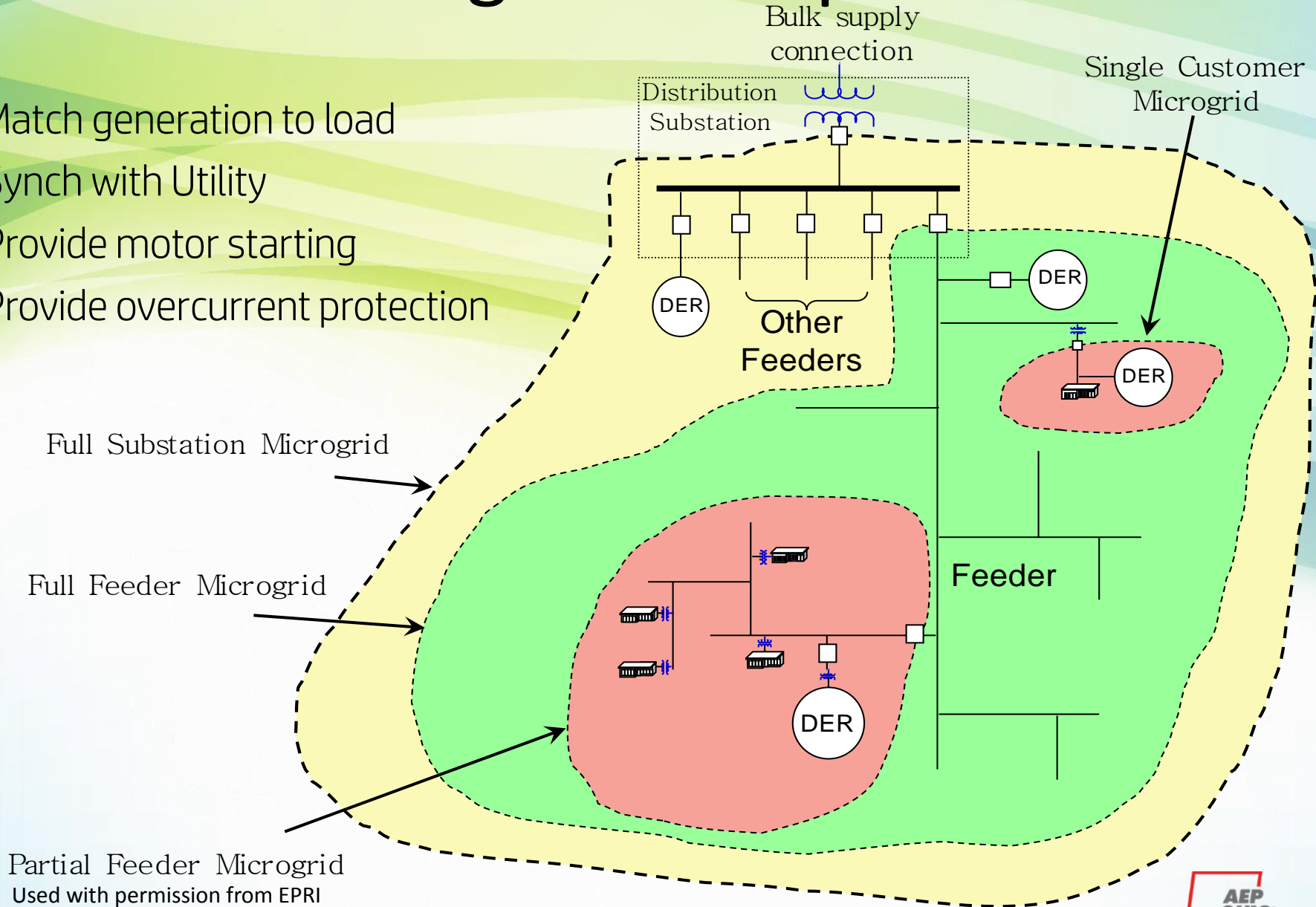


An aerial photograph of a city skyline at dusk. The sky is a mix of blue and orange, with clouds. The city buildings are illuminated, and their lights reflect on a river in the foreground. The river is calm, and the surrounding area has some greenery and a paved path.

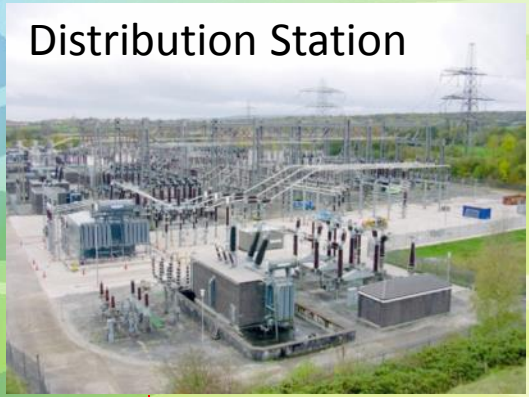
Microgrid overview

Microgrid Examples

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



Distribution Station



Microgrids



Smart Switch

Distribution Line



Solar / PV



Battery Storage

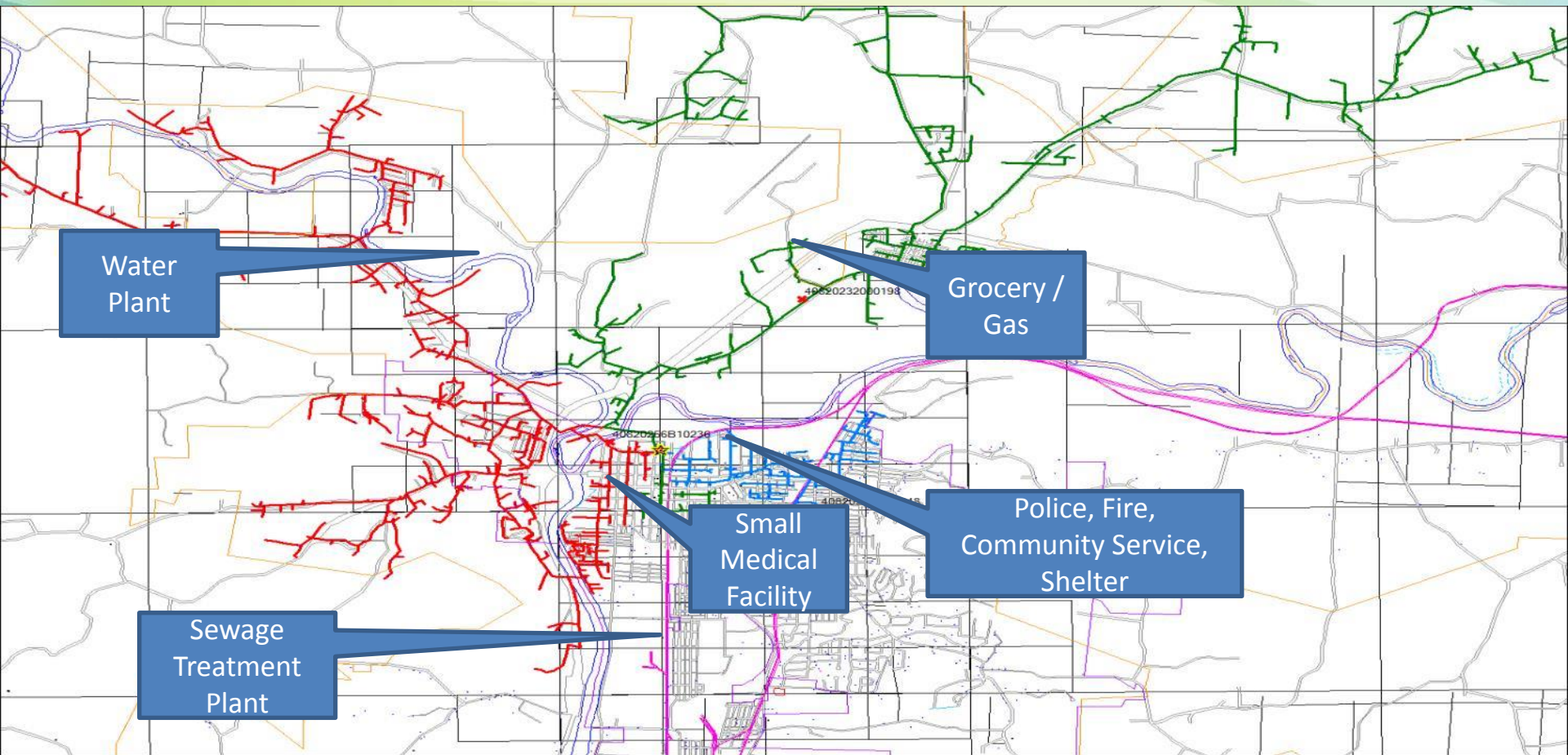


Critical Facility (Fire Station)

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.

An aerial photograph of a city skyline at dusk. The sky is a deep blue with scattered clouds. The city buildings are illuminated with warm lights, and their reflections are visible in a river in the foreground. The river flows from the bottom left towards the center right. The overall scene is a mix of urban architecture and natural elements like the river and sky.

Smart Street Lighting

Smart Street Lighting

■ Deploy appx. 202,000 Smart Street Lights



Smart Street lighting

Operations

Street Light
Monitoring
Software

Street
Light
Control
Software

Smart City Network

Communication
System

COMMS MODULE

CONTROL
NODE

CABINET

RTU

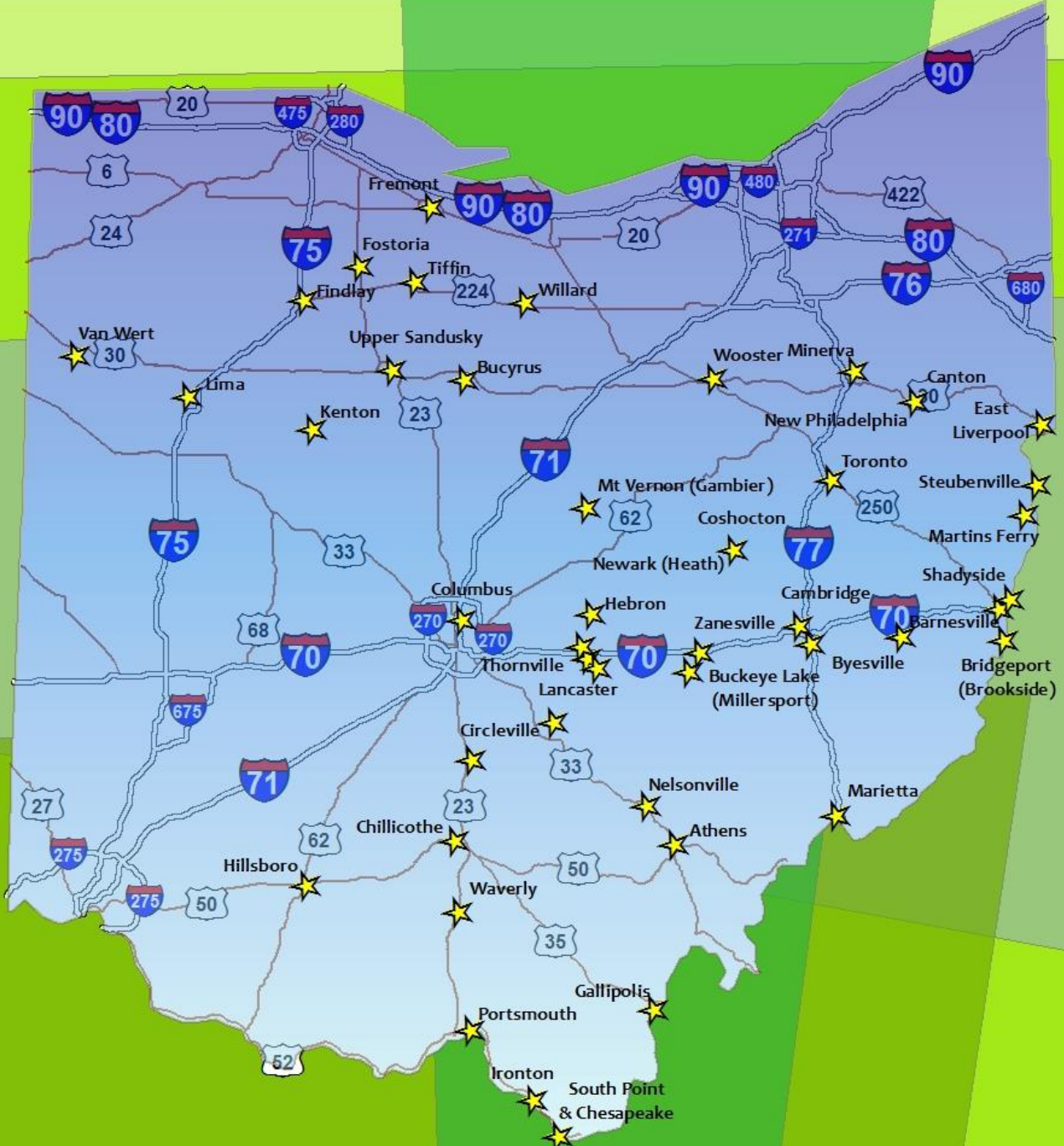
CABINET
CONTROLS

Smart City

INDIVIDUAL
CONTROLS

UP TO 100
STREET LIGHTS

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.

BENEFITS

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?

