Consortium for Energy Efficiency

Perspectives on the Potential Opportunities for Connected Water Heating

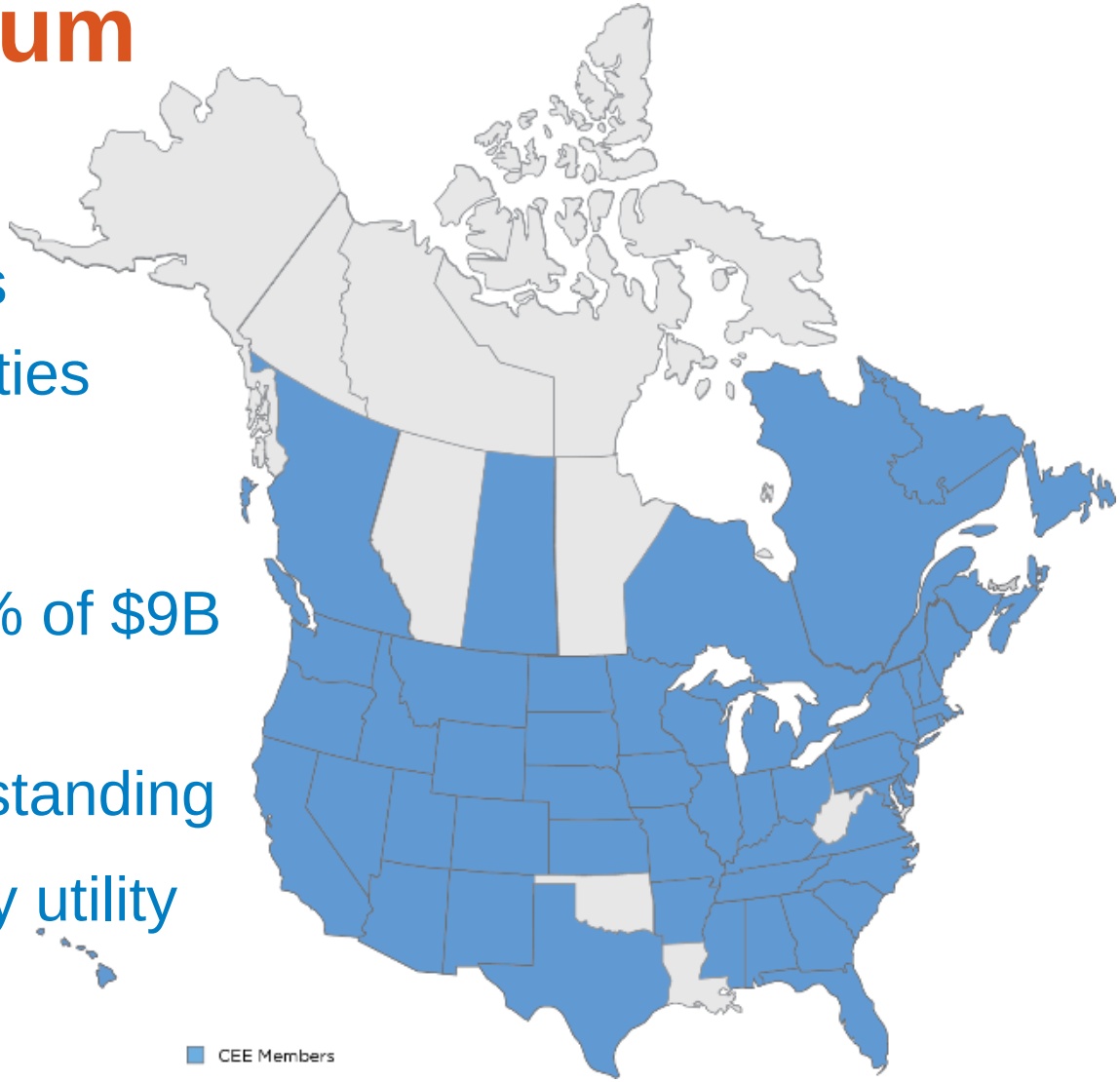
Alice Rosenberg
Senior Program Manager
March 21, 2018
Portland, OR

Agenda

- CEE and Binational Market Transformation
- Connected Value Proposition at Large
- Connected Water Heating Opportunities

The Consortium

- Focuses on transcendent needs
- Brings together utilities serving customer concentrations
- CEE members–80% of $9B industry
- Leverages earned standing
- Governed largely by utility executives



CEE Members Working Together

Program Administrators

Alabama Power
Alliant Energy
Ameren Illinois
Atmos Energy Corporation
Austin Energy
Avista
Baltimore Gas & Electric Company
BC Hydro
Berkshire Gas
Cape Light Compact
Columbia Gas of Massachusetts
Columbia Gas of Ohio
Commonwealth Edison Company
Connecticut Natural Gas
Consolidated Edison Company
Consumers Energy
DC Sustainable Energy Utility (DCSEU)
Dominion Energy Utah
DTE Energy
Duke Energy
Efficiency Maine
Efficiency Vermont
Énergir (Gaz Métro)
Energy Trust of Oregon
Eugene Water & Electric Board
Eversource
Focus on Energy—Wisconsin
FortisBC
Georgia Power
Great Plains Natural Gas
Gulf Power
Hawai'i Energy
Hydro One
Hydro-Québec
Idaho Power
Los Angeles Department of Water & Power
MidAmerican Energy Company
Mississippi Power
Montana-Dakota Utilities
National Grid
Natural Resources Canada
NB Power
Nebraska Public Power District
New Jersey Natural Gas
New Mexico Gas Company
New York State Energy Research and Development Authority
Nicor Gas
Northern California Power Agency
NW Natural
Oncor
Pacific Gas and Electric Company
PECO
PNM
Potomac Electric Power Company (Pepco)
PSEG Long Island
Puget Sound Energy
Sacramento Municipal Utility District
Salt River Project
San Diego Gas & Electric Company
SaskPower
Seattle City Light
Snohomish County PUD
SoCalGas
South Jersey Gas
Southern California Edison
Southern Connecticut Gas
Southern Minnesota Municipal Power Agency
Southwest Gas
Tacoma Power
Tampa Electric
TECO Peoples Gas
Tennessee Valley Authority
Union Gas
United Illuminating Company
Unitil
Vectren Ohio
Vermont Department of Public Service
Vermont Gas
Xcel Energy

Efficiency Organizations National Laboratories

American Council for an Energy-Efficient Economy
California Institute for Energy and Environment
Fraunhofer Center for Sustainable Energy Systems
Lawrence Berkeley National Laboratory
Massachusetts Department of Energy Resources
National Renewable Energy Laboratory
Natural Resources Defense Council
Northeast Energy Efficiency Partnerships
Northwest Energy Efficiency Alliance
Oak Ridge National Laboratory
Pacific Northwest National Laboratory
Southwest Energy Efficiency Project

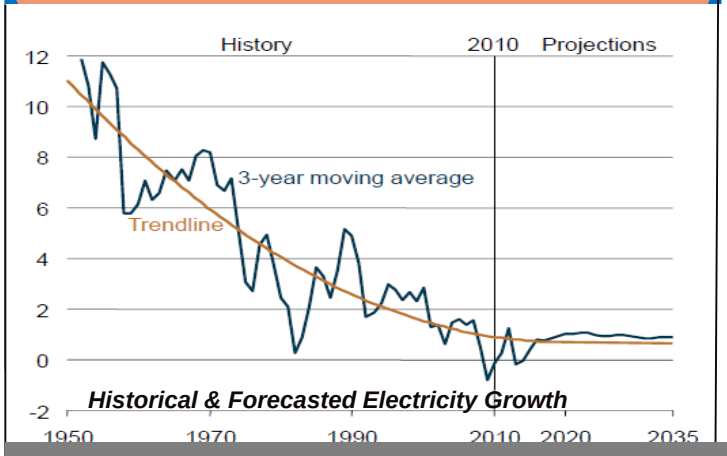
Federal Advisors

Natural Resources Canada
US DOE
US EPA

Some Dynamics Utilities Face

Declining Electric Load Growth

- Energy efficiency and conservation have become a part of the general culture
- Growth of customer self-generation



Historical & Forecasted Electricity Growth

Utilities are challenged under the existing regulatory model

Need for Increased Investment

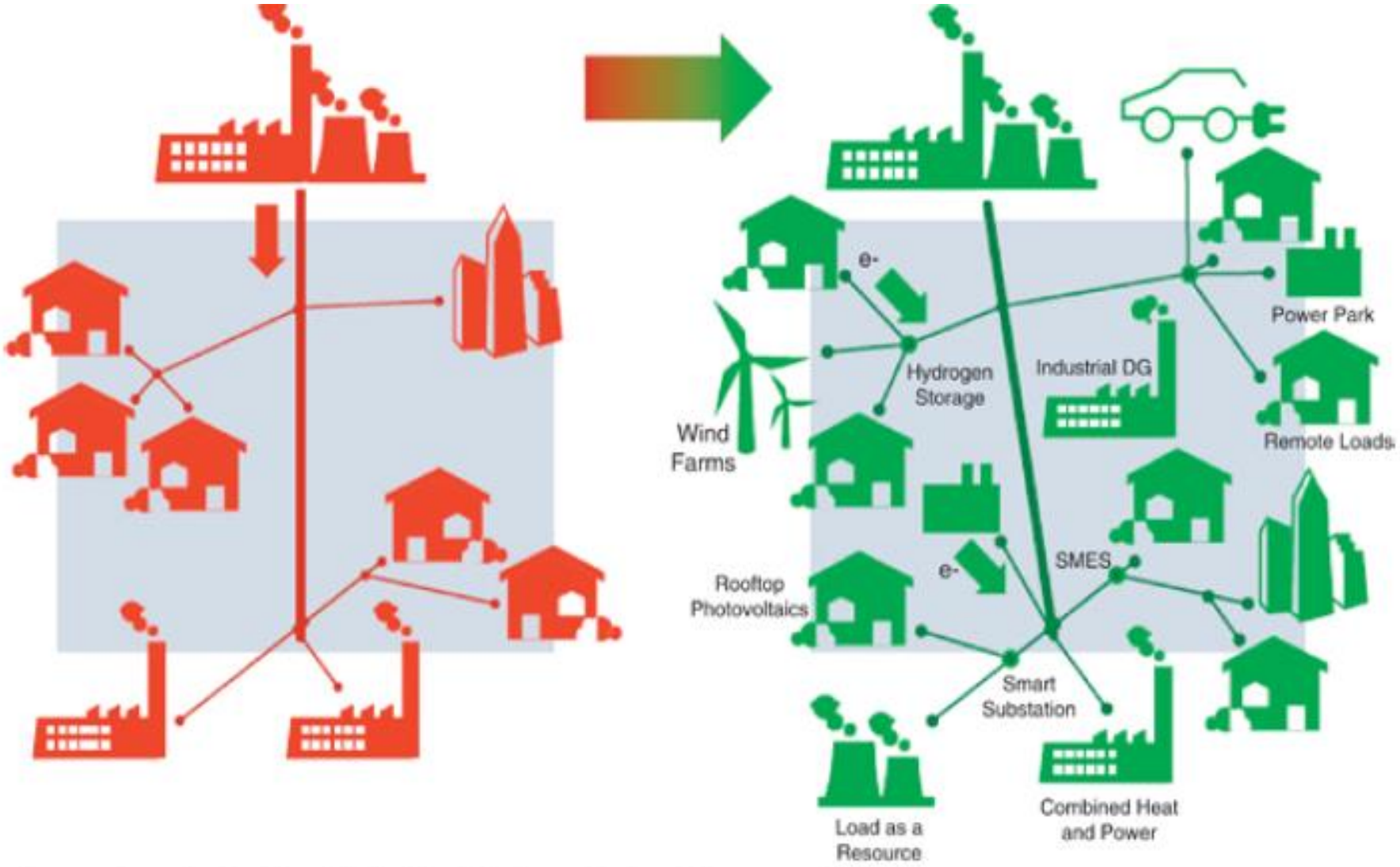
- Customer desire greater reliability/ resiliency (post Superstorm Sandy, etc.)
- General aging infrastructure
- Usage control technologies (Smart Grid)
- Cybersecurity

Disruptive Technologies

- Greater Distributed Generation
- Battery storage evolving and being piloted
- Electric vehicle penetration is increasing

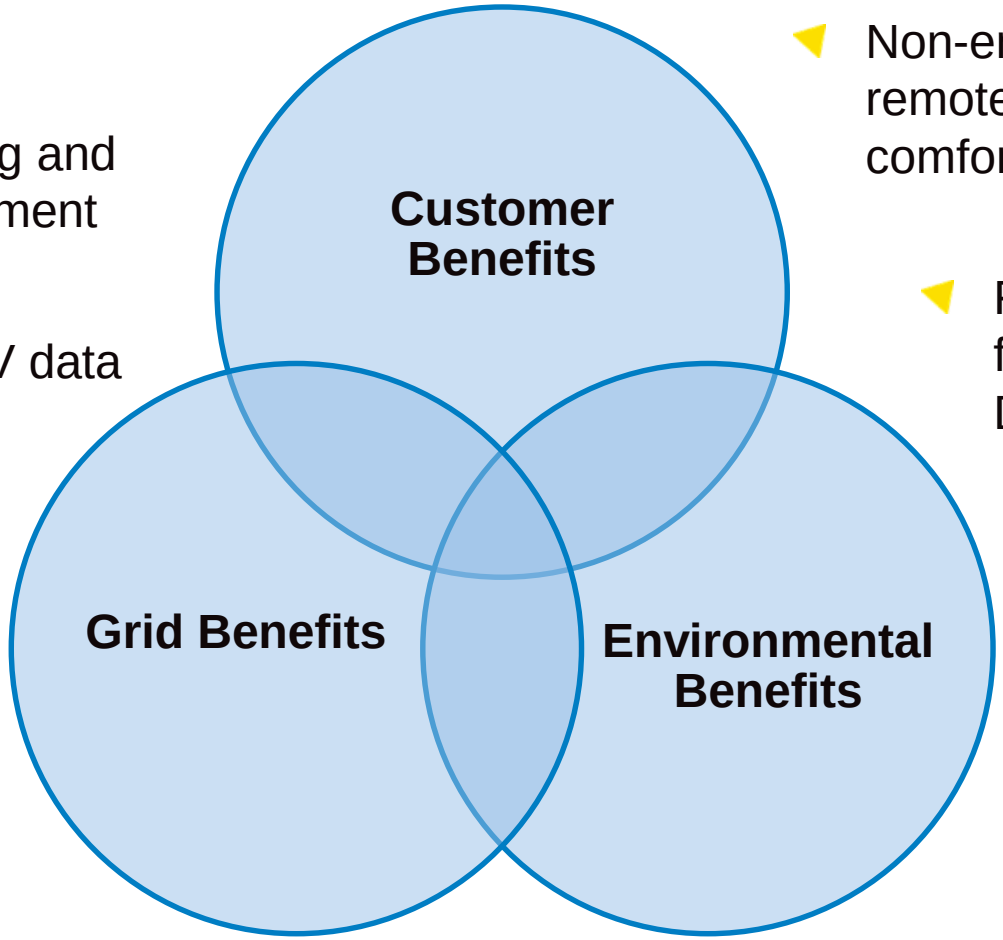
Grid Quality Credit Quality

Utility of the Future: In Concept



Source: Journal of Database Marketing & Customer Strategy Management (2010)

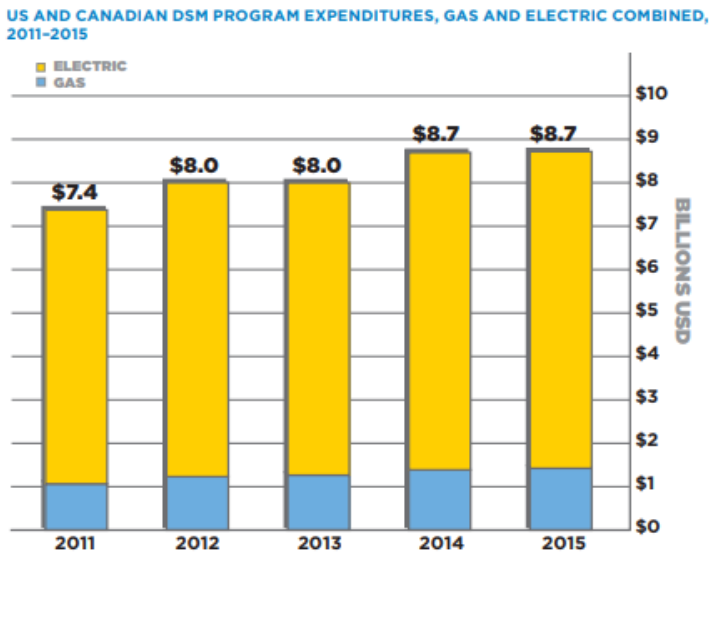
Potential Benefits of Connected

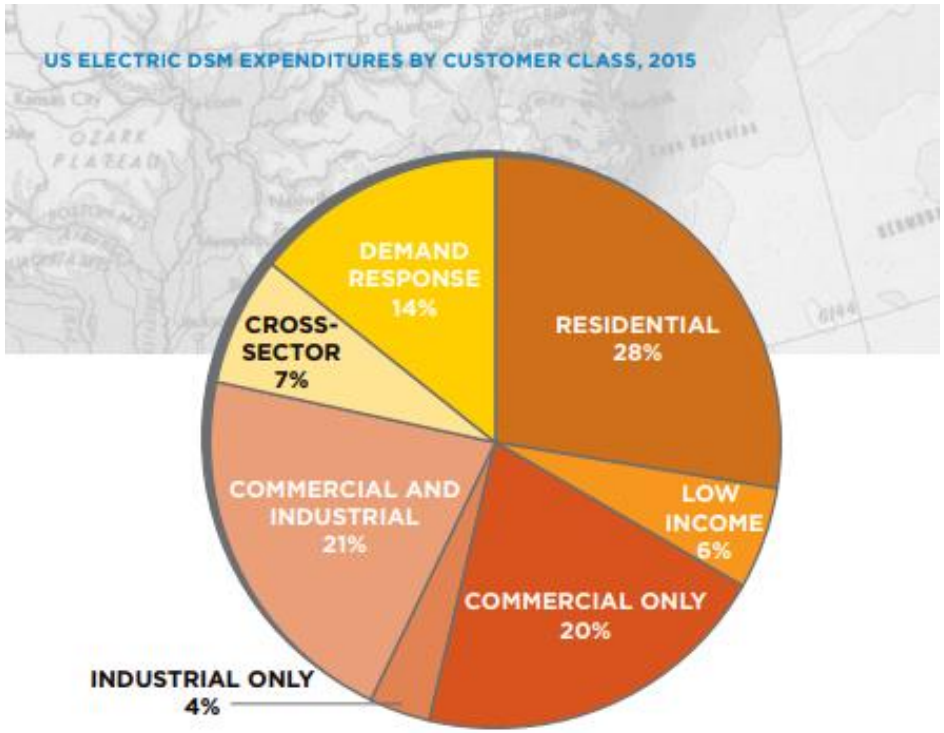


- Grid balancing and load management
- Program M&V data
- Enhanced customer engagement
- Ancillary services
- Non-energy benefits: remote control, enhanced comfort, health/wellness
- Financial savings from new EE and DR opportunities
- Air quality/ carbon
- New Integrated DSM program offerings

Investment in Load Management

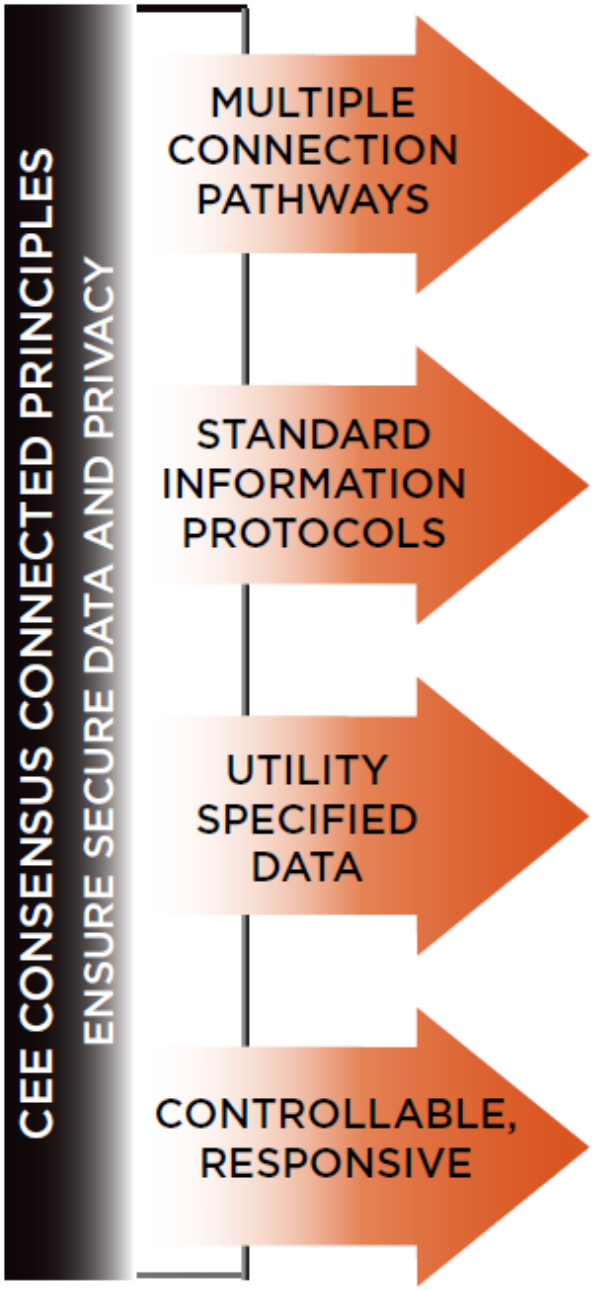
- "In 2015 US electric demand response (DR) expenditures totaled **over $855 million** from ratepayer funded sources only"





Source: CEE 2016 State of the Efficiency Program Industry

Creating the IDSM Platform—CEE View



COOPERATION WITH

AHRI

ENERGY STAR

ENERGY INTENSIVE PRIORITY PRODUCT CATEGORIES

CENTRAL HVAC

APPLIANCES

POOL PUMPS

WATER HEATING

CENTRALIZED HEMS

LIGHTING

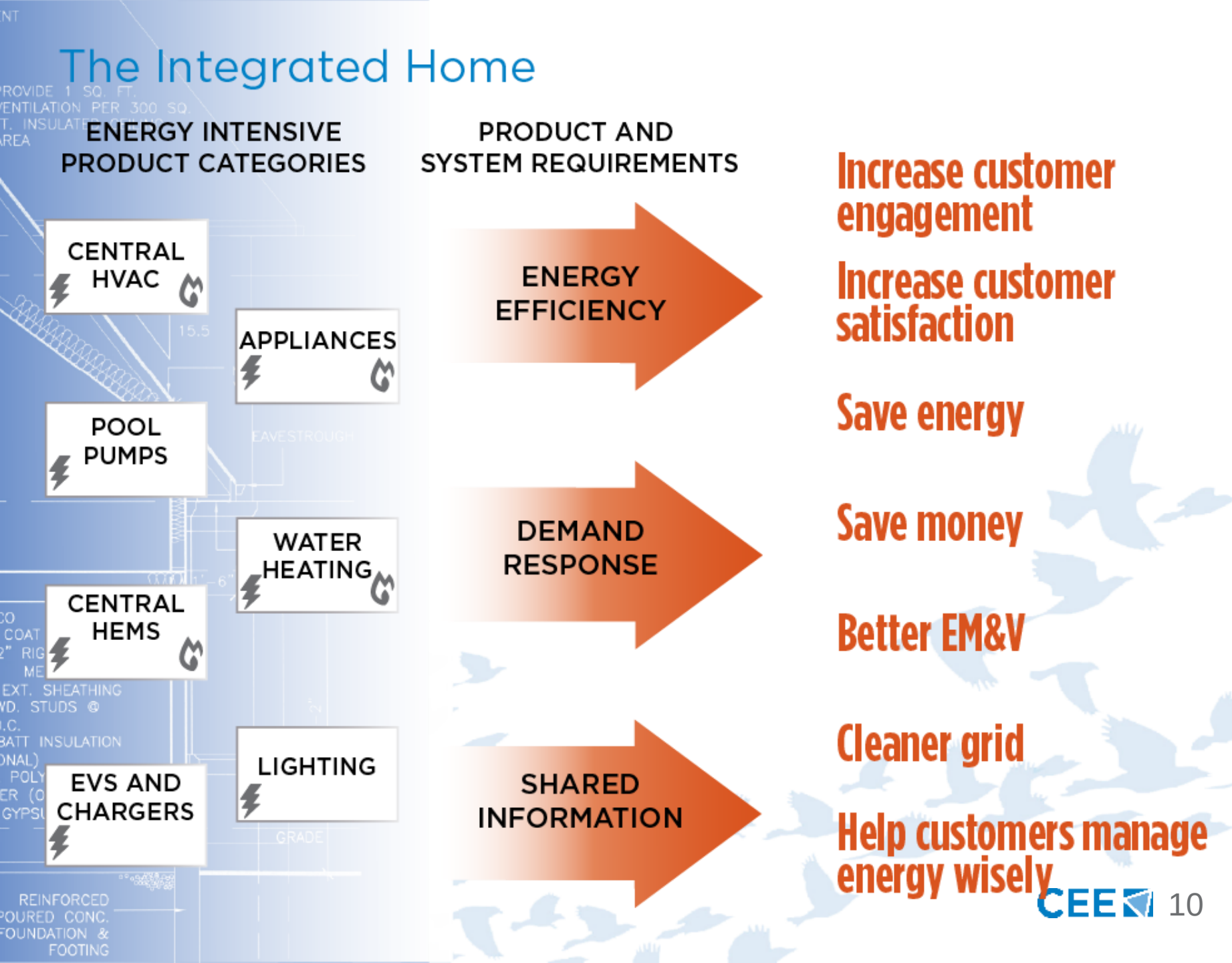
EVS AND CHARGING STATIONS

Managing for Grid Value

Managing for Customer Value

Managing for EM&V Value

The Integrated Home



Consensus Reached

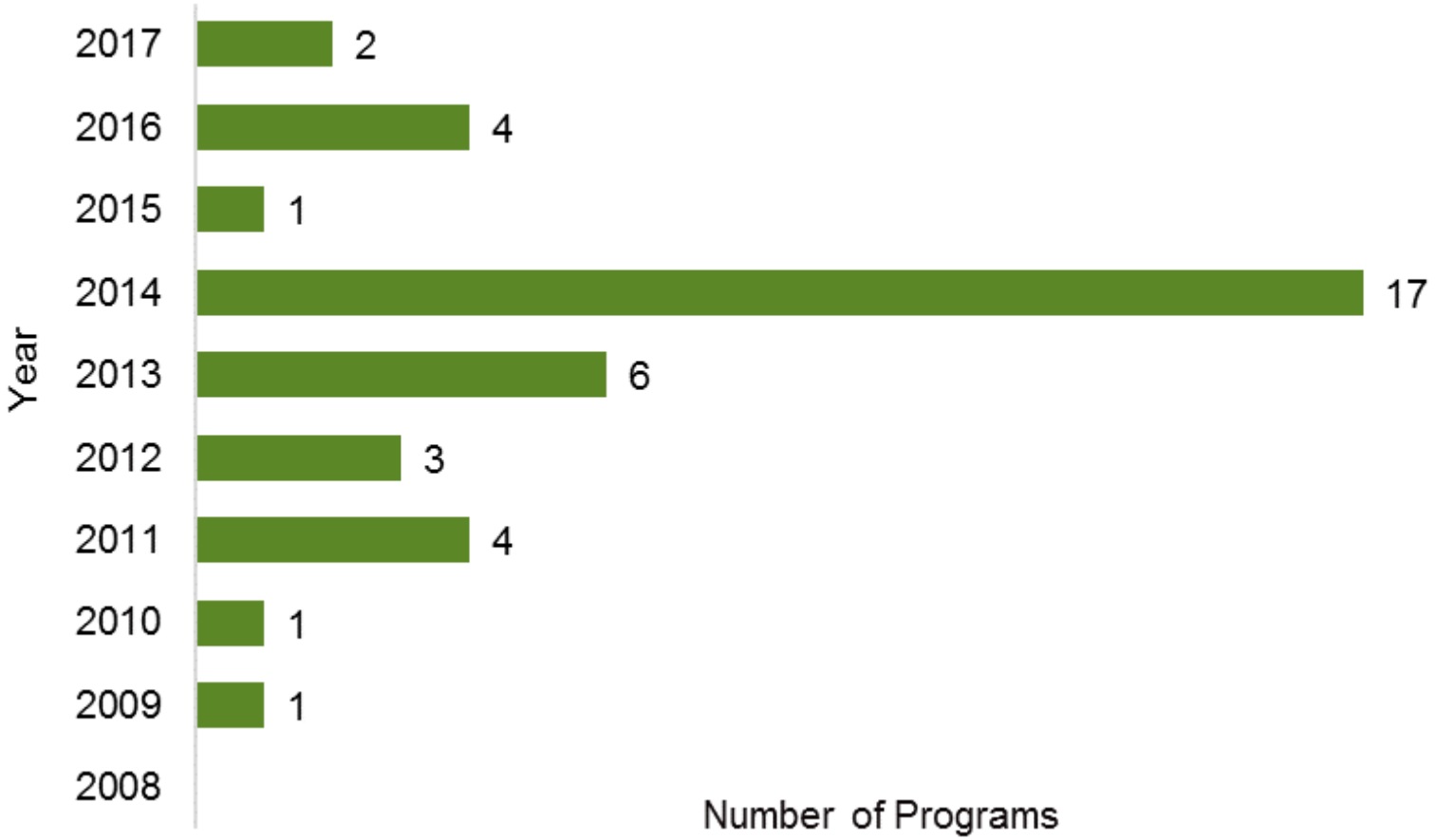
- Use of **open, non-proprietary, communication standards** to achieve interoperability are required….
- Establishing **multiple pathways to connect** is likely necessary to ensure the majority of consumers realize benefits…
- Maintaining a **direct line of site** to connected products at the "substation level" will maximize the load management benefits…
- Acceptable communication pathways must **secure customer data** and adequately protect privacy…
- Products are "controllable" and **responsive to price signals**…
- Connected devices must be "discoverable" and **disclose their ability for a utility signal** (or equivalent) to reach the connected product consistently…
- Capability to share **basic energy data** is required

Res Water Heating Program Context

- Rising baselines → decreased savings delta
- Increasingly stringent portfolio goals and targets
- Demand for grid benefits and customer amenities
- More members promoting HPWHs
  - 59 active programs as of 2017

Launch of Member HPWH Programs

Year that CEE Member HPWH Programs Were Established



Source: CEE 2017 Residential Water Heating Program Summary

CEE HPWH Connected Criteria

Definition and Key Aspects

- Must meet HPWH efficiency requirements first
- Optional; can apply to any tier

Connectivity

- On-Premise, Open Standards Connectivity
- Open Access

Load Management Capabilities

- Application ACK (acknowledgement)
- Application NAK (negative acknowledgement)
- Outside communication connection status
- End shed/run normal
- Shed
- Critical peak event
- Grid emergency
- Present relative price
- Autonomous cycling and terminating cycling
- Load up
- Get/set user preference level
- Customer override
- Query and response operational state
- Query and response: device information request
- Get/set commodity read request and reply
- Get present water temperature

Consumer Override

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Manufacturer Perspectives on Smart Water Heaters

Aykut Yilmaz

ACEEE Hot Water Forum

March 22, 2018

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AHRI and Smart Systems

- AHRI is a trade association representing over 90 percent of the North American HVACR and water heating industry.
- Published AHRI White Paper: “Smart” Systems
  - Available for download at www.ahrinet.org
- Developing draft AHRI Standard 1380P, *Demand Response through Variable Capacity HVAC Equipment in Residential and Small Commercial Applications*
  - Participants include CEE, EPA, and EPRI
  - Sets methods of test and additional communications protocols for both OpenADR and CTA 2045 to confirm demand response capabilities

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Standardization considerations

- Development driven by utility requirements
  - Varying specifications create barriers to entry and limit choice
  - Intermediaries are bridging these gaps, but at added cost
- Growing consensus around OpenADR and CTA 2045
  - AHRI members participated in development of both
  - More common in utility specifications
  - Consistency of requirements can help open market to new manufacturers
- Concerns with standardization
  - Need to allow for future innovation
  - Some manufacturers have built-in capabilities, and CTA 2045 compliance could add costs
  - Allow other communication protocols?

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Current State of Smart Water Heating

- Large, electric-resistance water heaters are still the tool of choice
  - Product class = “Grid-enabled Water Heater”. Among other things, U.S. law requires:
    - Heater to be >75 gal water volume
    - Manufacturers to provide activation lock with water heater
      - New interaction between utility and manufacturer
      - Added time required to deploy systems
    - Heater to provide < ½ of stated First Hour Rating if locked.
  - Else, >55 gal electric water heater must be a heat pump.
  - Electric resistance has advantages over heat pumps
    - More capacity when utilities need to shed demand or store excess energy
    - More predictable performance when trying to meet varying utility and consumer demands
- Good experience so far in managing these programs
  - Requires installer education
  - Utilities should share lessons learned

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Manufacturer interests for Smart Water Heaters

- Meeting consumer expectations
  - Basic performance: hot water when needed
    - Manufacturers need ability to define own protocols to react to utility requests
    - Two-way communication is better than one-way or on-off systems
    - Easier to manage for electric resistance; heat pump performance less understood
  - Security
  - Tinker-toys for techies
    - Requires accessible interface, such as Wi-Fi
- Cost to consumer
  - Upfront Cost
    - Few consumers are interested in premium features and willing to pay extra cost
    - Demand response technology almost entirely driven and supported by utility incentives
  - Lifetime Costs
    - Potential to save money over time with utility incentives
    - Time-of-use pricing schemes

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Manufacturer interests for Smart Water Heaters

- Brand integrity
  - Benefit: demand-response capability is “green” and/or “hi-tech”
    - Limited by relative obscurity of water heater in homeowners day-to-day activities
  - Costs: damage to reputation if water heater cannot meet advertised capacity claims
    - Could lead to legal liability
    - Mitigated by utility notification to homeowner when peak demands are expected
- Increase in service calls – will need utilities’ help
- Data collection
  - Value added especially for new technology
  - Comes with security and confidentiality concerns

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Thank you!

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Communication Interfaces and the Connected Device

Chuck Thomas
EPRI

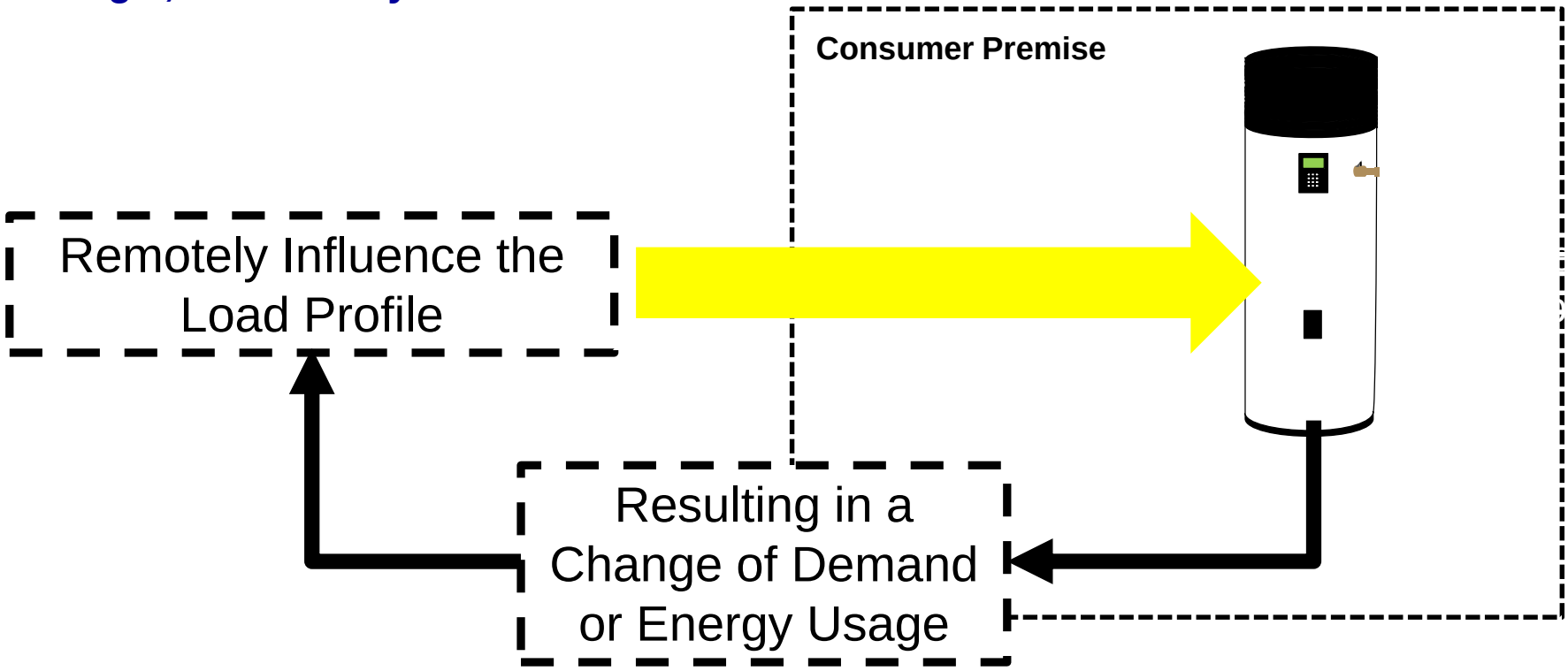
ACEEE Hot Water Forum 2018, Portland Oregon
March 21st , 2018

Purpose

This presentation was compiled to share knowledge gained over 10-years of research that focused on developing, testing and deploying new communication technologies and implementation guidelines to enable OEMs to mass produce end-use devices with embedded load management capabilities that can interoperate with ANY network, ANY third-party energy management application to provide consumers with the option of using “off-the-shelf” purchased products to provide energy services (grid services) for monetary or environmental purposes.

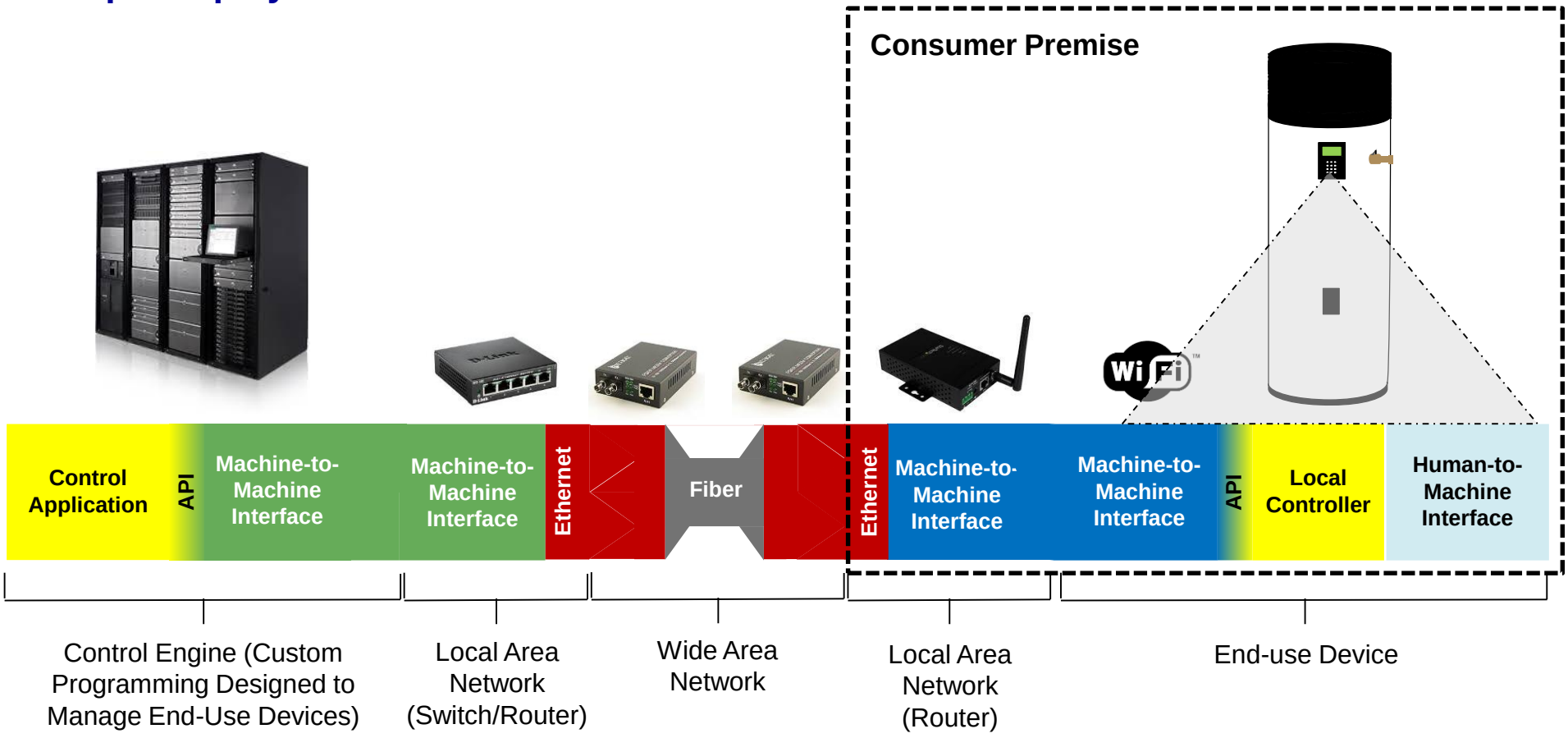
Connected Device Architecture Overview

The Challenge , to Remotely Influence End-use Device



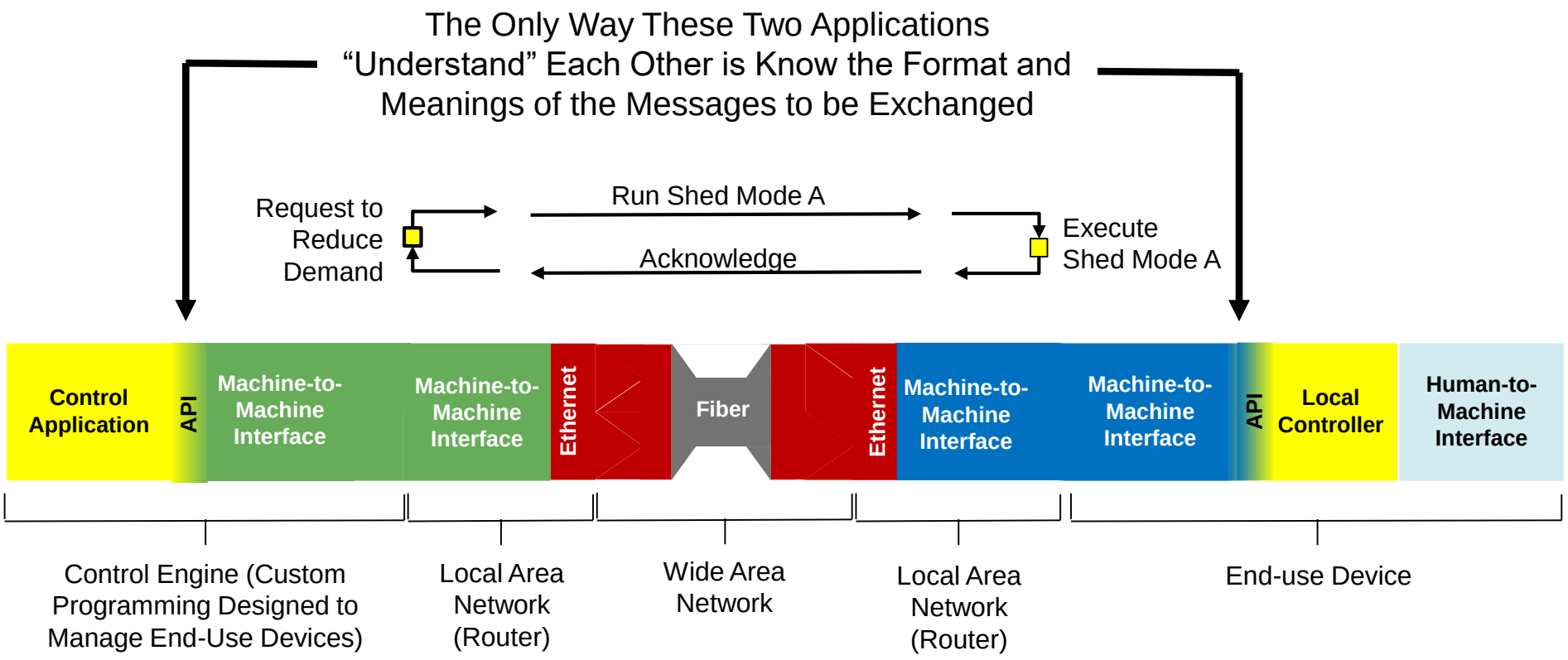
Connected Device Architecture Overview

Example Deployment



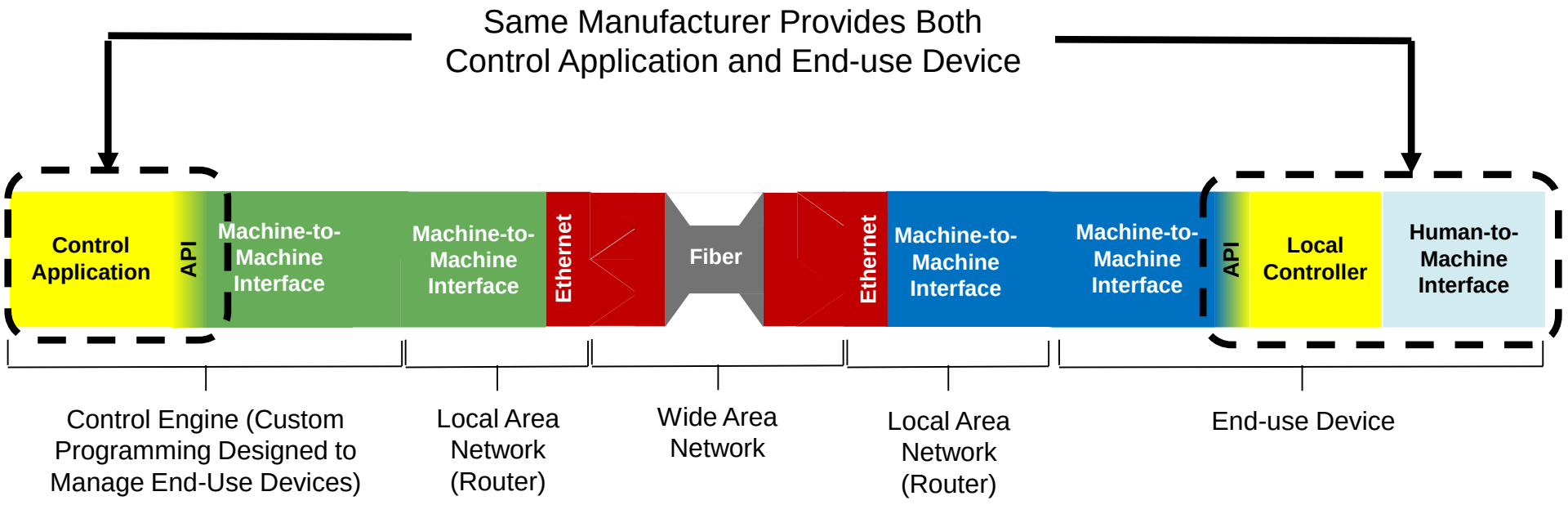
Connected Device Architecture Overview

Remote Application and End-use Device MUST Understand Each Other



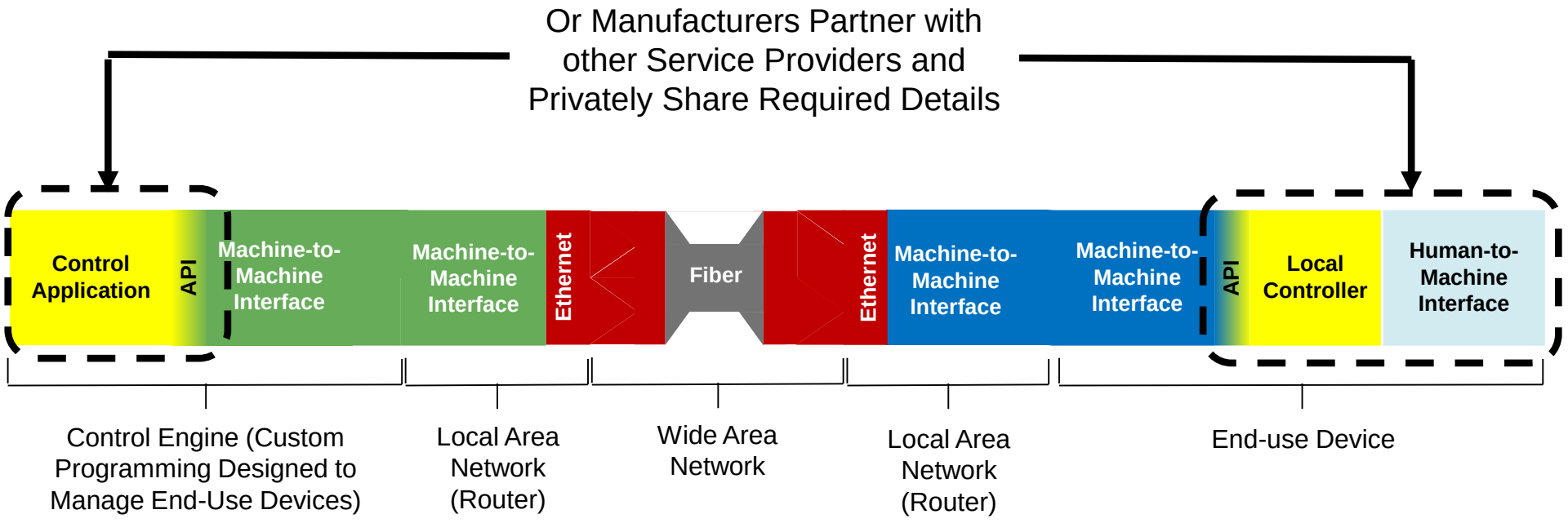
Connected Device Architecture Overview

Example1 – Vertical Integration



Connected Device Architecture Overview

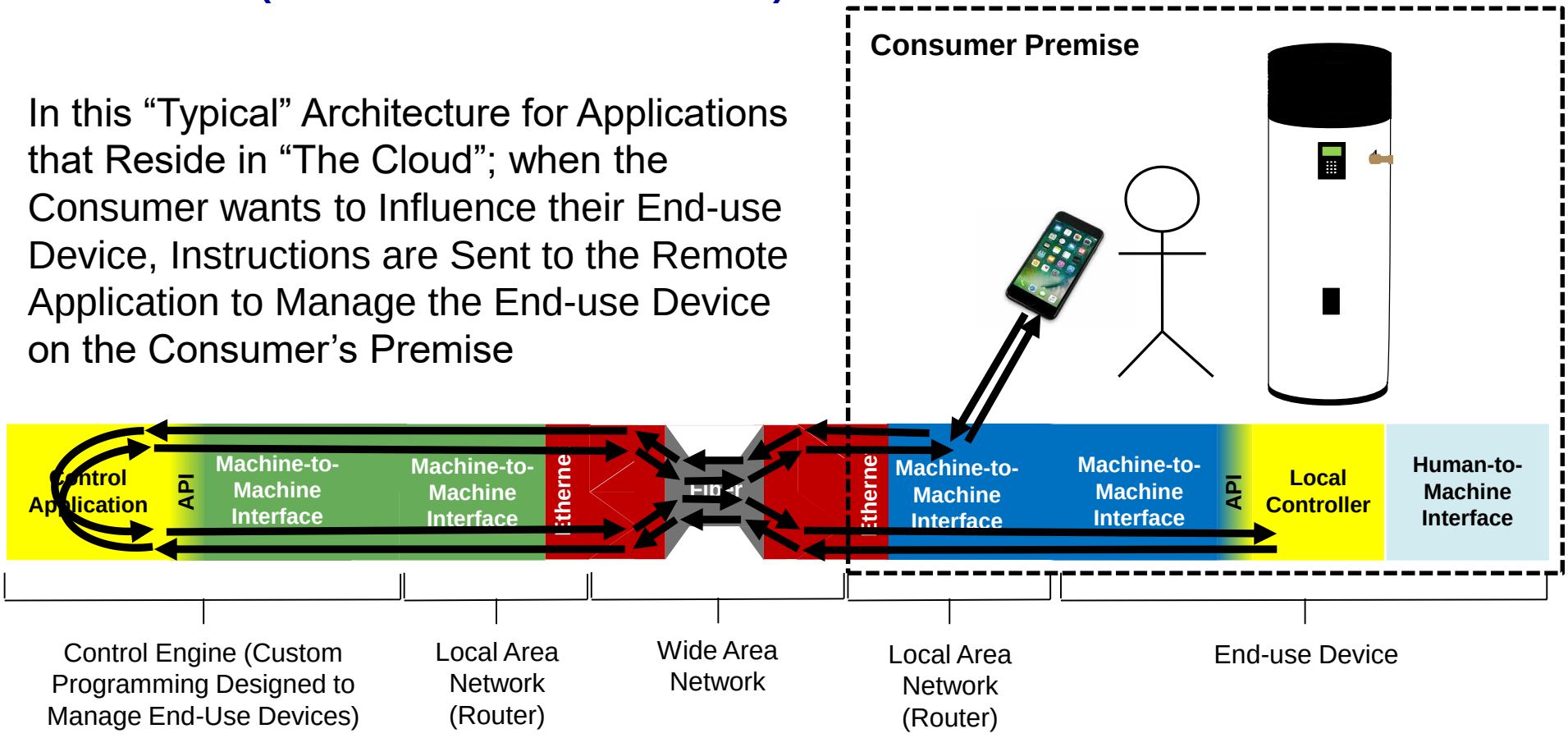
Example2 – Vertical Integration



Connected Device Architecture Overview

The Data Path (Consumer to End-use Device)

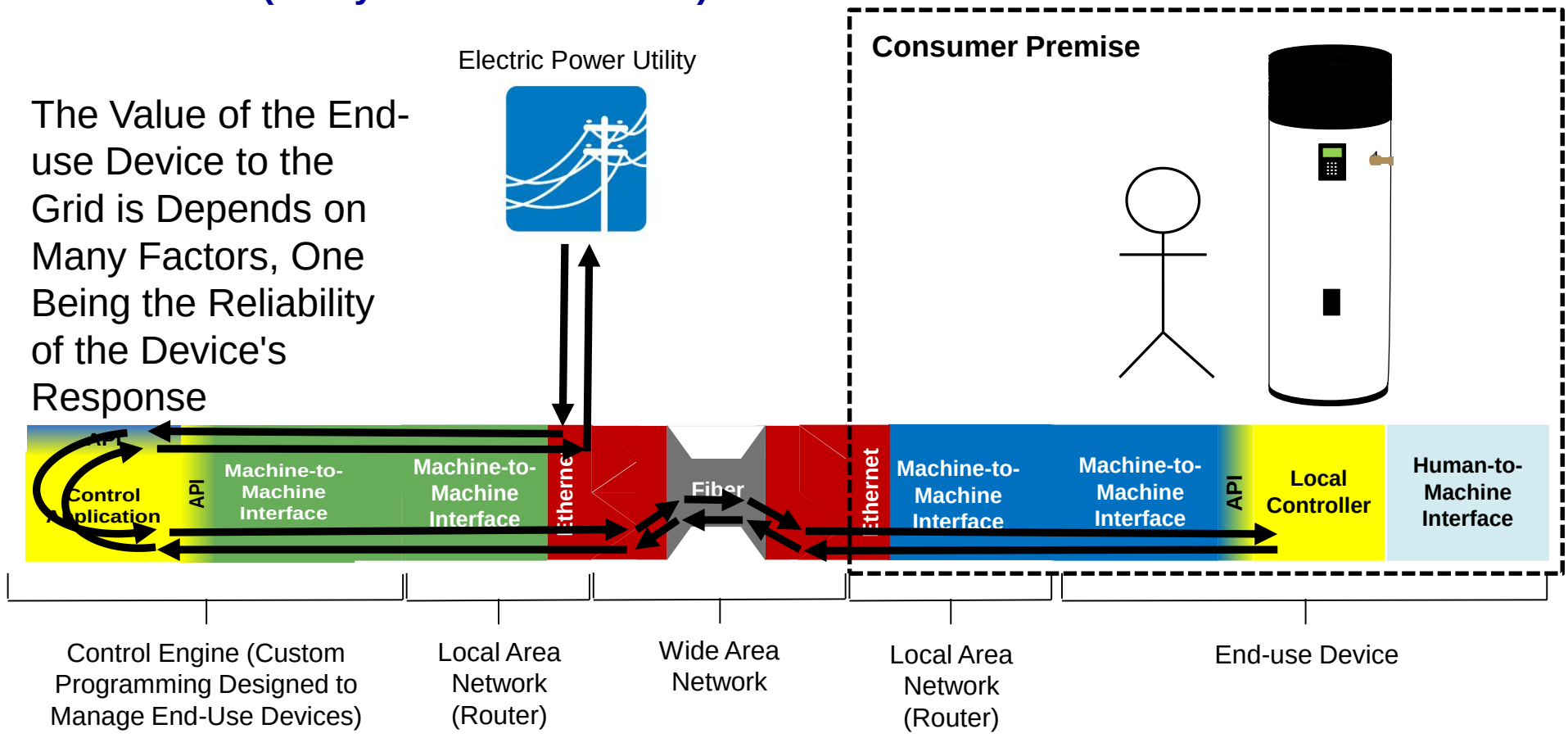
In this “Typical” Architecture for Applications that Reside in “The Cloud”; when the Consumer wants to Influence their End-use Device, Instructions are Sent to the Remote Application to Manage the End-use Device on the Consumer’s Premise



Connected Device Architecture Overview

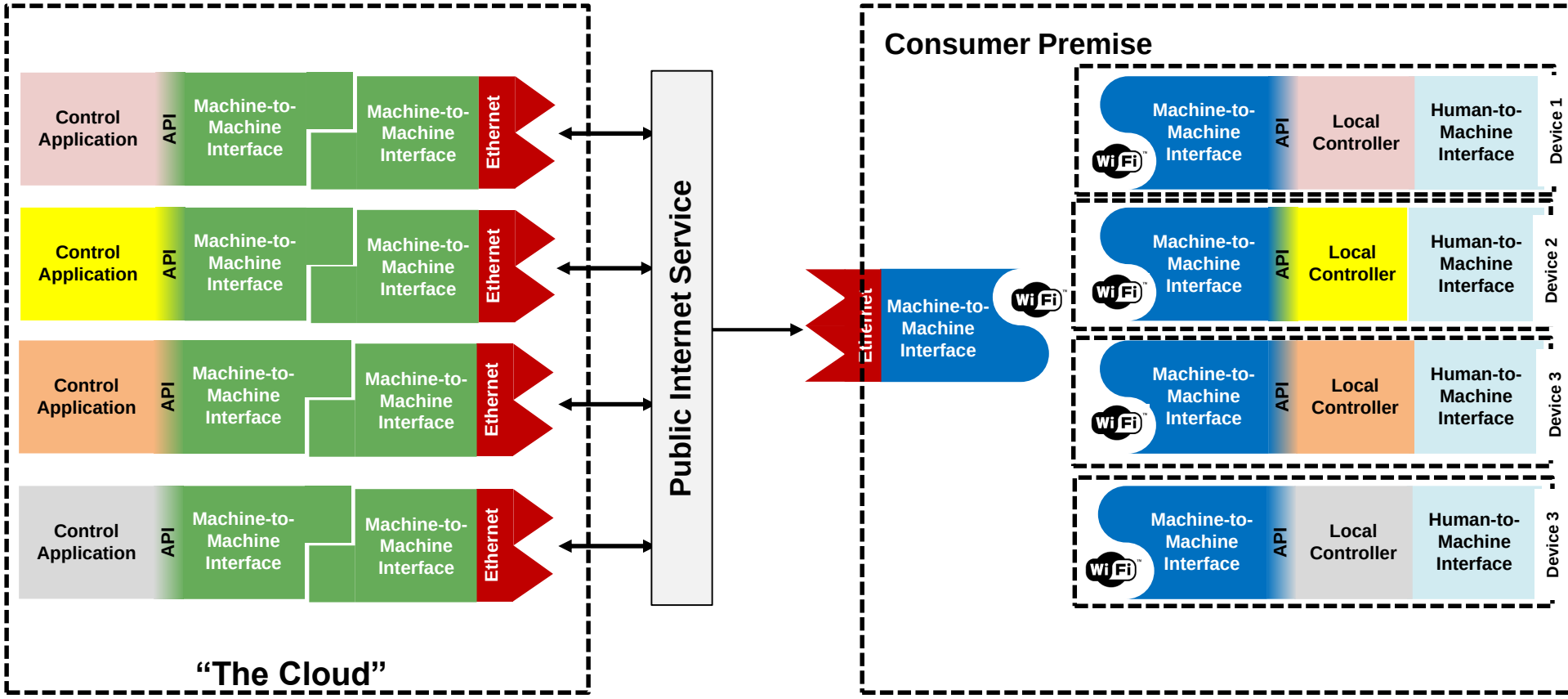
The Data Path (Utility to End-use Device)

The Value of the End-use Device to the Grid is Depends on Many Factors, One Being the Reliability of the Device's Response



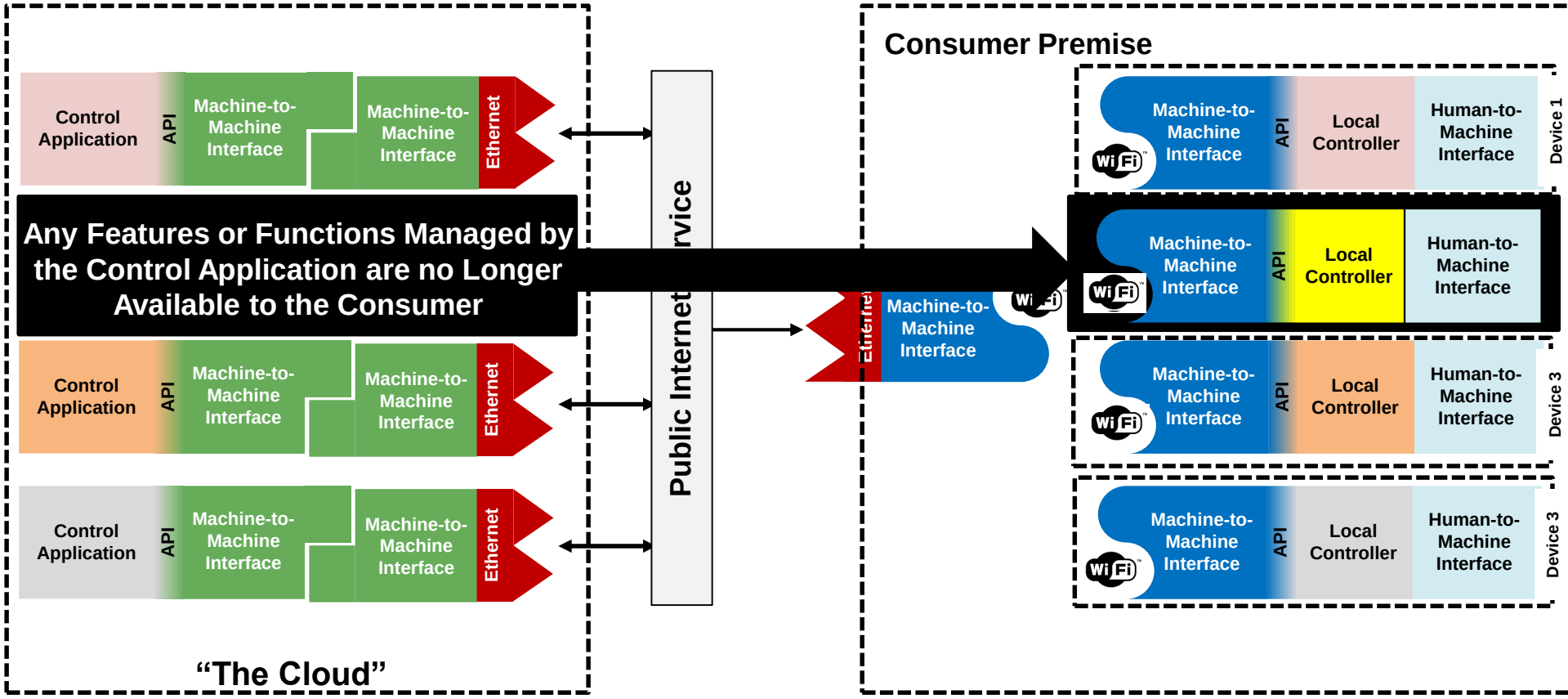
Connected Device Architecture Overview

Stranded Assets Scenario



Connected Device Architecture Overview

Stranded Assets (Loss of OEM or Third-party Service Provider Application)



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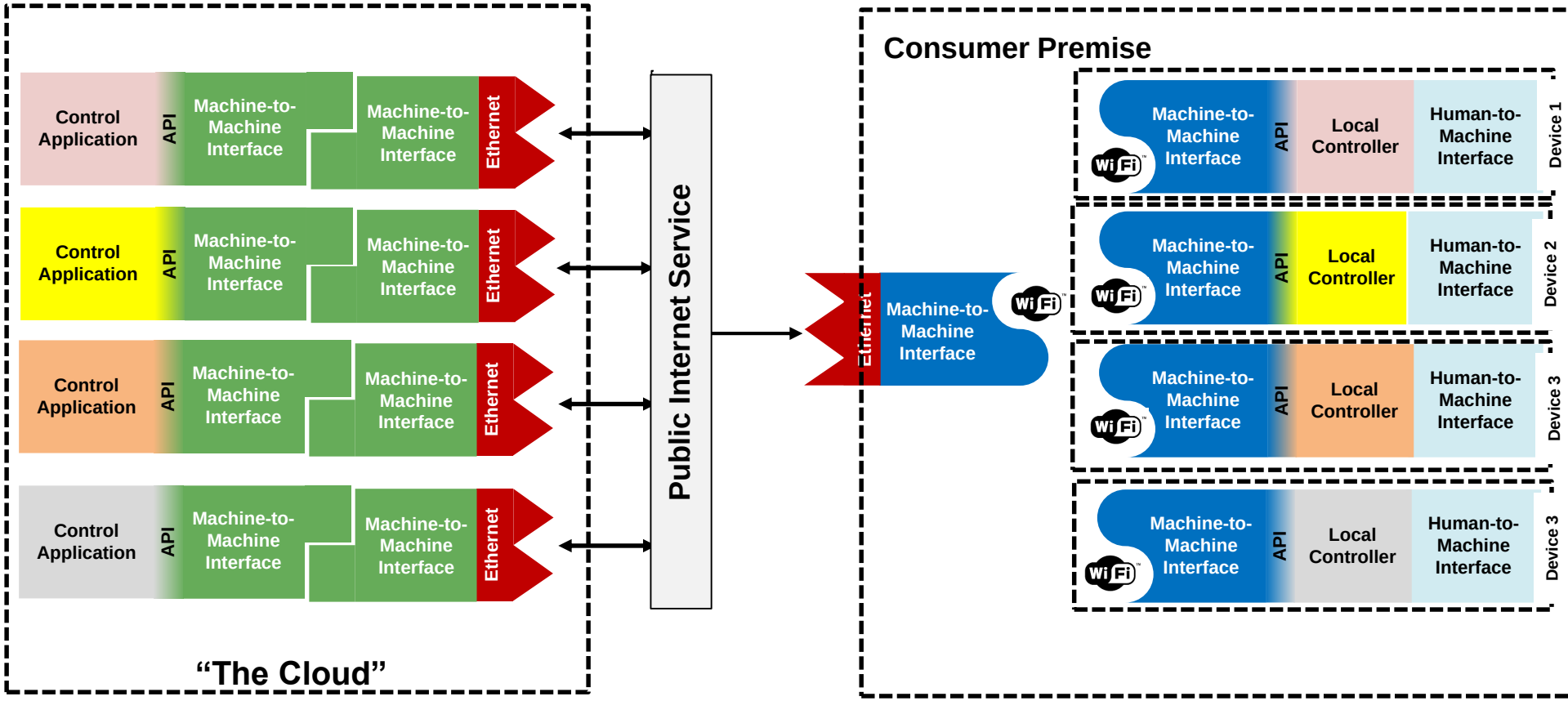
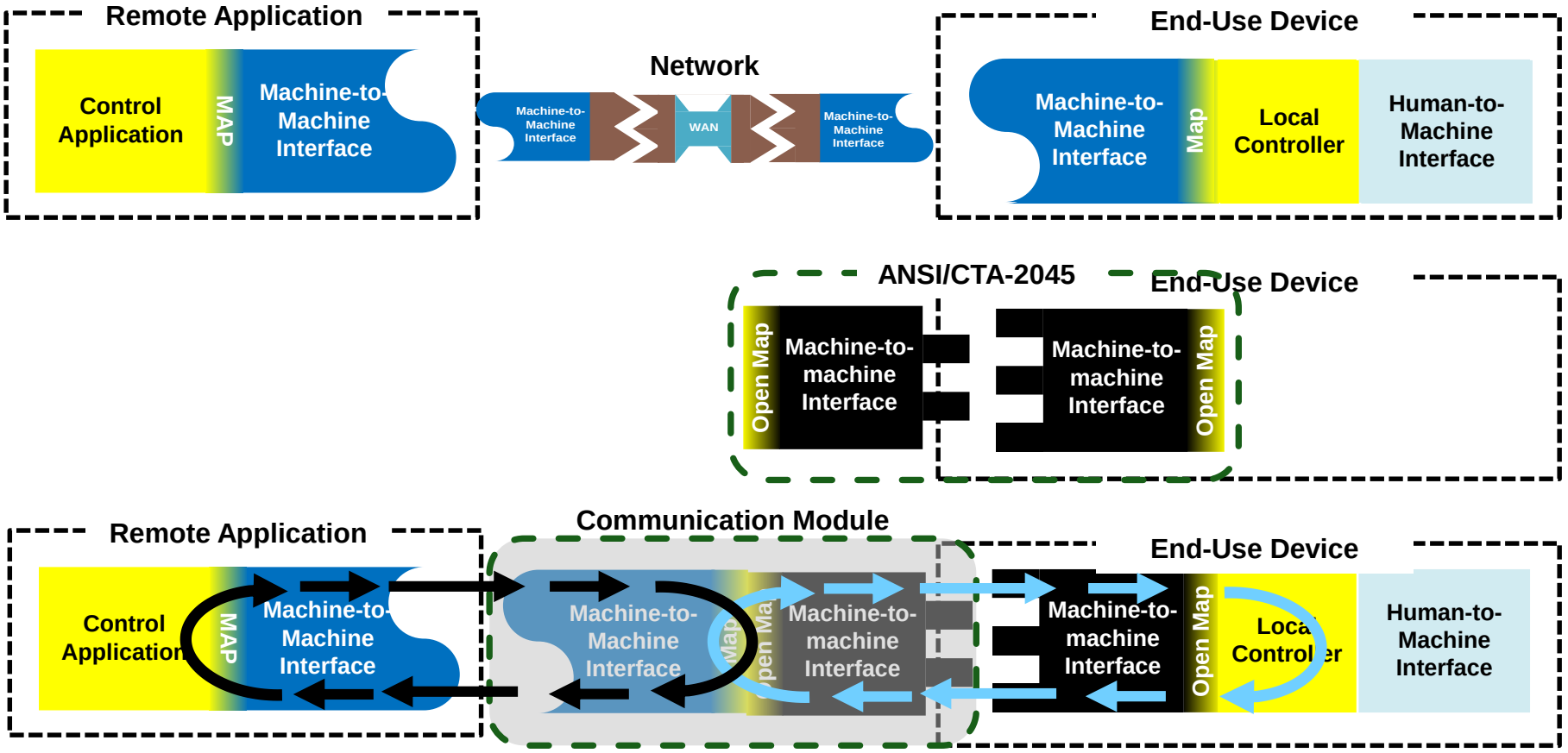
Connected Device Architecture Overview

Stranded Assets (Local Area Network Update)



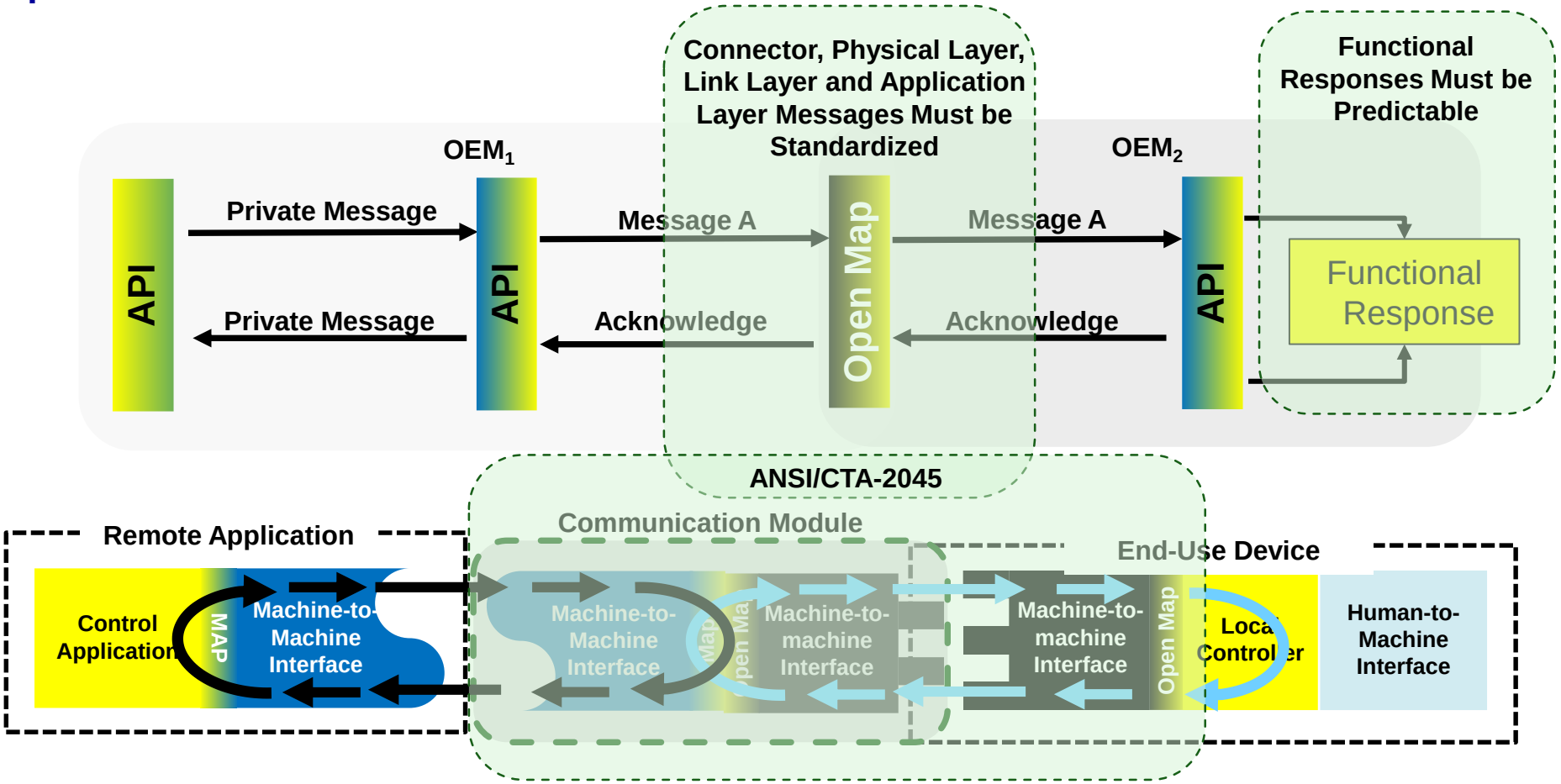
Connected Device Architecture Overview

Open Communication Port



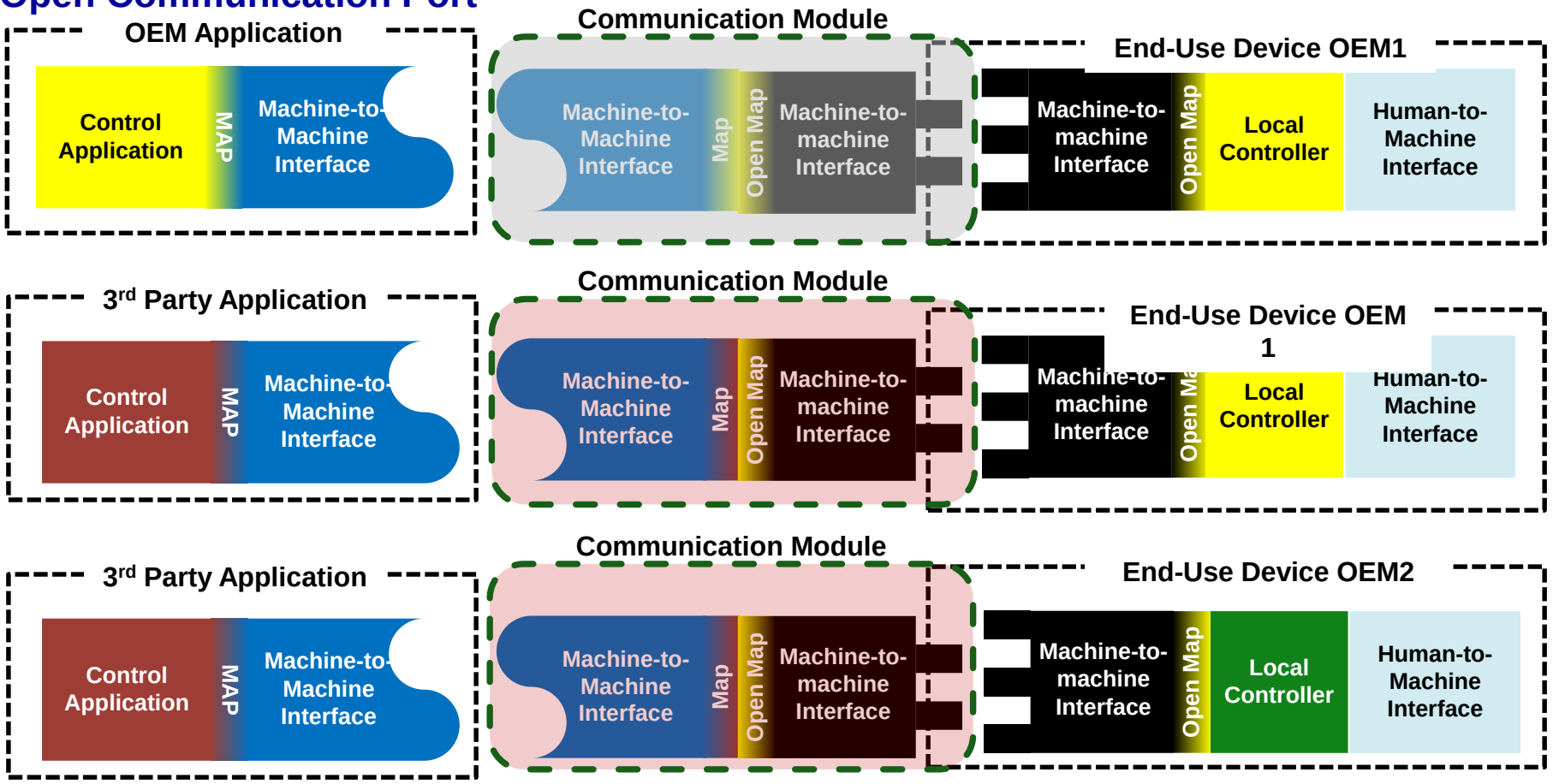
Connected Device Architecture Overview

Open Communication Port



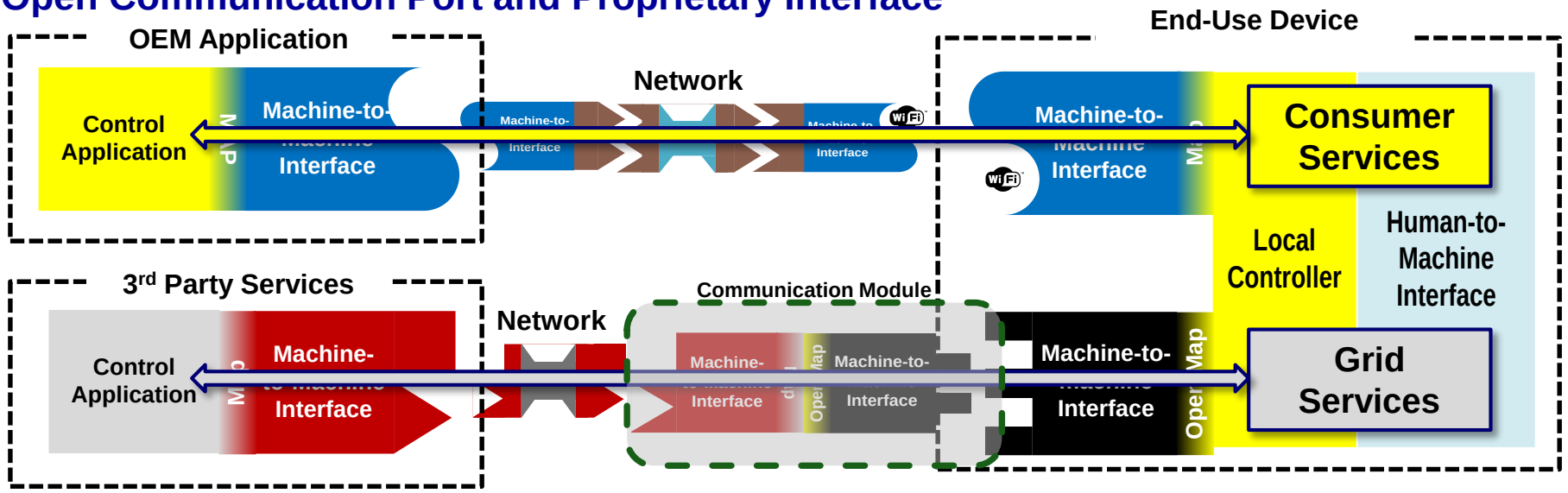
Connected Device Architecture Overview

Open Communication Port



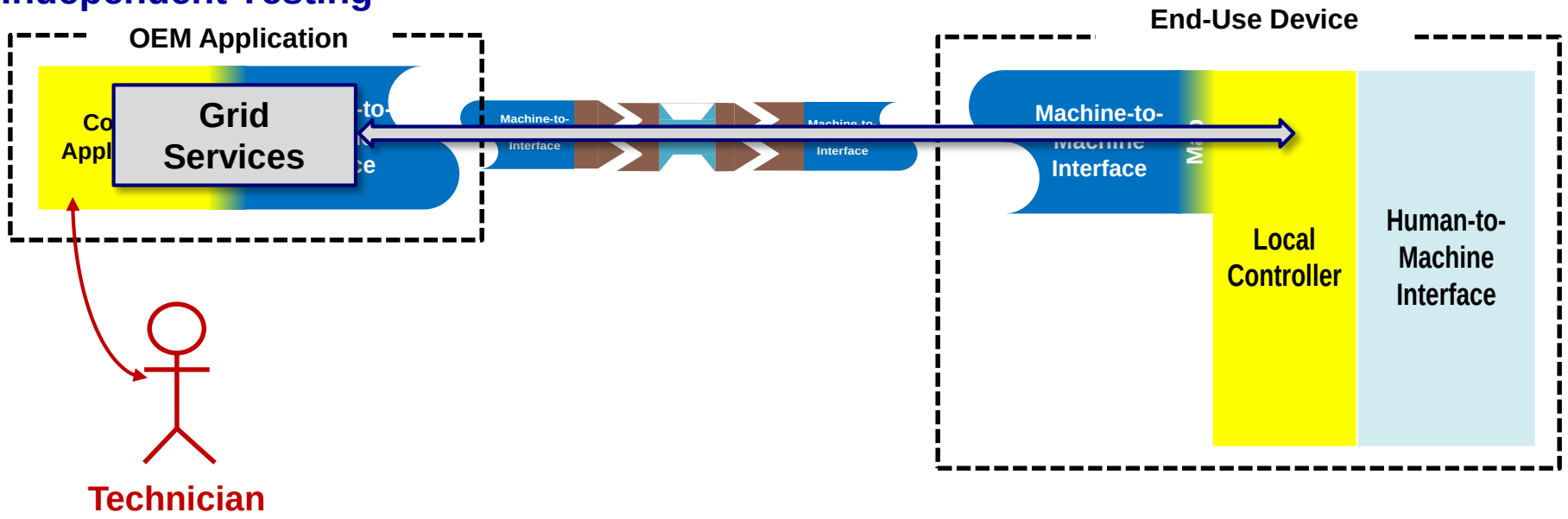
Connected Device Architecture Overview

Open Communication Port and Proprietary Interface



Connected Device Architecture Overview

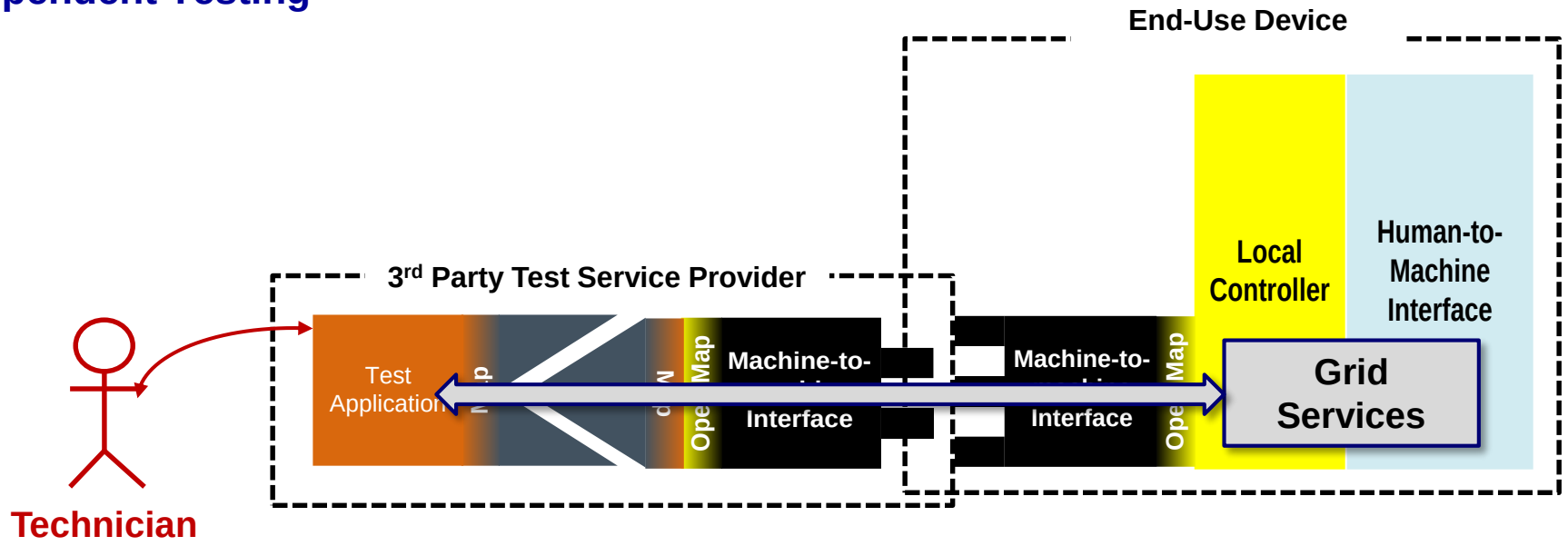
Independent Testing



- In Order to Test Grid Services, the Technician must have access to the OEM Application
- Certification or Compliance of Grid Services Applies only to the OEM Application Version Number Tested
- Variation between OEM Applications Decreases the Confidence Level of the Test Results

Connected Device Architecture Overview

Independent Testing



- **A Standardized Test Harness Can be Used by ANY Technician**
- **Since Grid Services are Embedded into the End-use Device, the Technician can Independently Test the End-use Device**
- **Test Applications and Procedures can be Customized then Standardized to Support different Connected Specifications**

Together…Shaping the Future of Electricity

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Chuck Thomas leads EPRI's Buildings-to-Grid, Homes-to-Grid, Devices-to-Grid Integration Research

Specializing in Automated Controls, Communication Protocols, Lab and Field Test of Emerging Technologies

Additional Slides

Optional Connected Criteria

- Criteria Scope

  Products must meet the scope and efficiency requirements set forth under “Heat Pump Water Heaters” in the Initiative’s Electric Qualification Criteria.

- Connected Electric HPHW Definition and Key Aspects

  To claim compliance with the CEE Connected Criteria, a connected heat pump water heater must include the device plus at least one communication interface at the device level that conforms with an open communication standard, to enable the product owner or an authorized third party to monitor and predictably execute load management functions as defined in Section D. Manufacturers may also choose to include an additional interface that may or may not use open communication standards to provide load management and other services. The product must continue to comply with the applicable product safety standards; the inclusion of the functionality described below shall not supersede existing safety protections and functions.

- Connectivity

  - **On- On-Premise, Open Standards Connectivity:** CEE requires that a product must enable economical and direct, on-premise, open standards-based translation using the physical and data-link layers of an industry-accepted, modular communication interface such as ANSI/CTA-2045-A. The open standards interface must be combined with an open standards communication module. Manufacturers may also choose to include a secondary communication interface to facilitate load management or other services that may be proprietary to the manufacturer or a designated third party.
  - **Open Access:** Manufacturers must provide any documentation that is required for the product owner or any third party to develop technologies to connect to the device’s communication interface.

Optional Connected Criteria – cont.

Load Management Capabilities

- Application ACK (acknowledgement)
- Application NAK (negative acknowledgement)
- Outside communication connection status
- End shed/run normal
- Shed
- Critical peak event
- Grid emergency
- Present relative price
- Autonomous cycling and terminating cycling
- Load up
- Get/set user preference level
- Customer override
- Query and response operational state
- Query and response: device information request
- Get/set commodity read request and get/set commodity read reply
- Get present water temperature

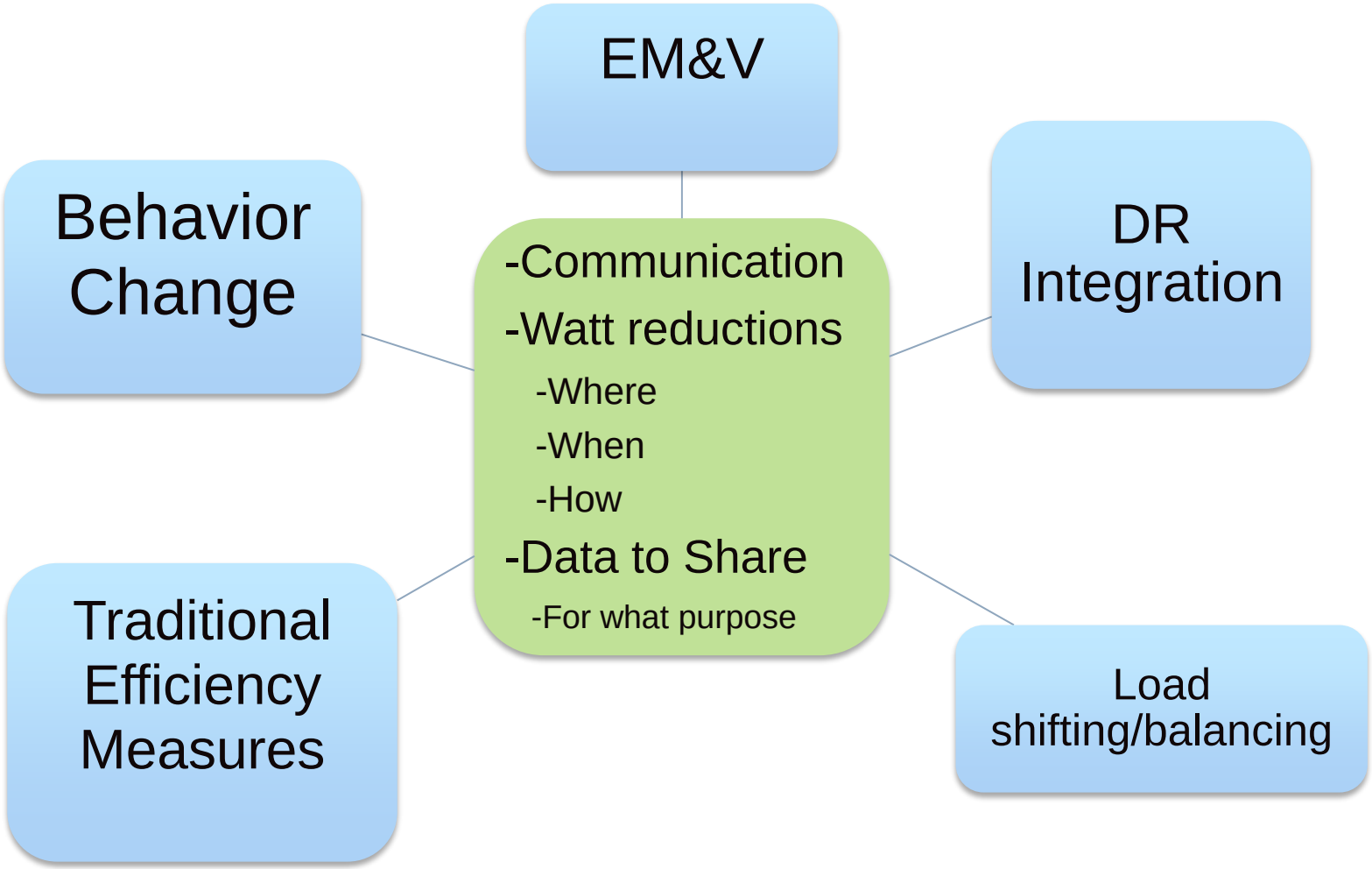
Consumer Override

Consumer Override Consumers shall be able to temporarily override their product's response to any current and future load management signals. The override status must be made available through the open communication interface. Upon expiration of the override, the product shall automatically return to the user-selected operational mode.

Potential Elements to Standardize

- Acceptable communication architecture and protocols
- Connection resiliency
- Customer data security and privacy
- Ability to ascertain physical location
- Product is discoverable by program administrator networks once registered
- Demand response availability: status and ability to participate
- Demand response functionality and response times
- Peak period avoidance configurability
- Data reporting capabilities
- Binary fault detection

Connected Products May Enhance DSM Programs



Connected Pilots and Programs

- Breakdown of 112 CEE member connected efforts in 2017

Figure 2: Efforts by Product Type