

SMART METERS



SMART GRID & SMART METER ARCHITECTURE

Tom Wilson, BSEE

Green and Healthy Homes

Wireless Safety Summit

Washington DC, Oct. 5, 2011



HOW CAN THIS LITTLE METER BE SUCH A **BIG PROBLEM?**

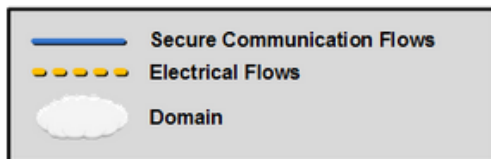
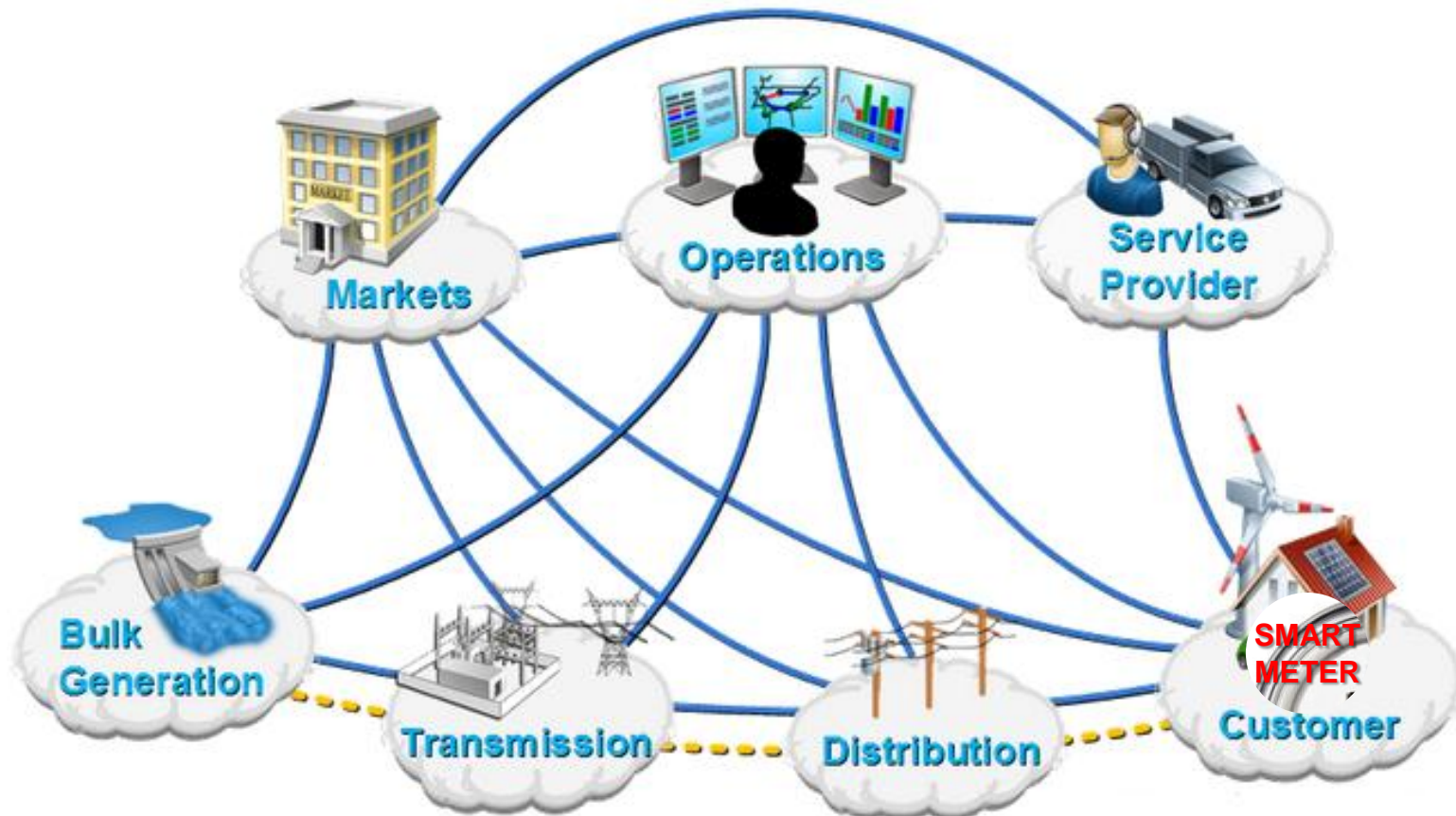


OUTLINE

- 1) SMART GRID OVERVIEW**
- 2) SMART METERS**
- 3) SMART METER EXPOSURE LEVELS**
- 4) SMART METER MITIGATION**
- 5) SMART METERS ISSUES**
- 6) SUMMARY**

SMART GRID OVERVIEW

SMART GRID REFERENCE ARCHITECTURE

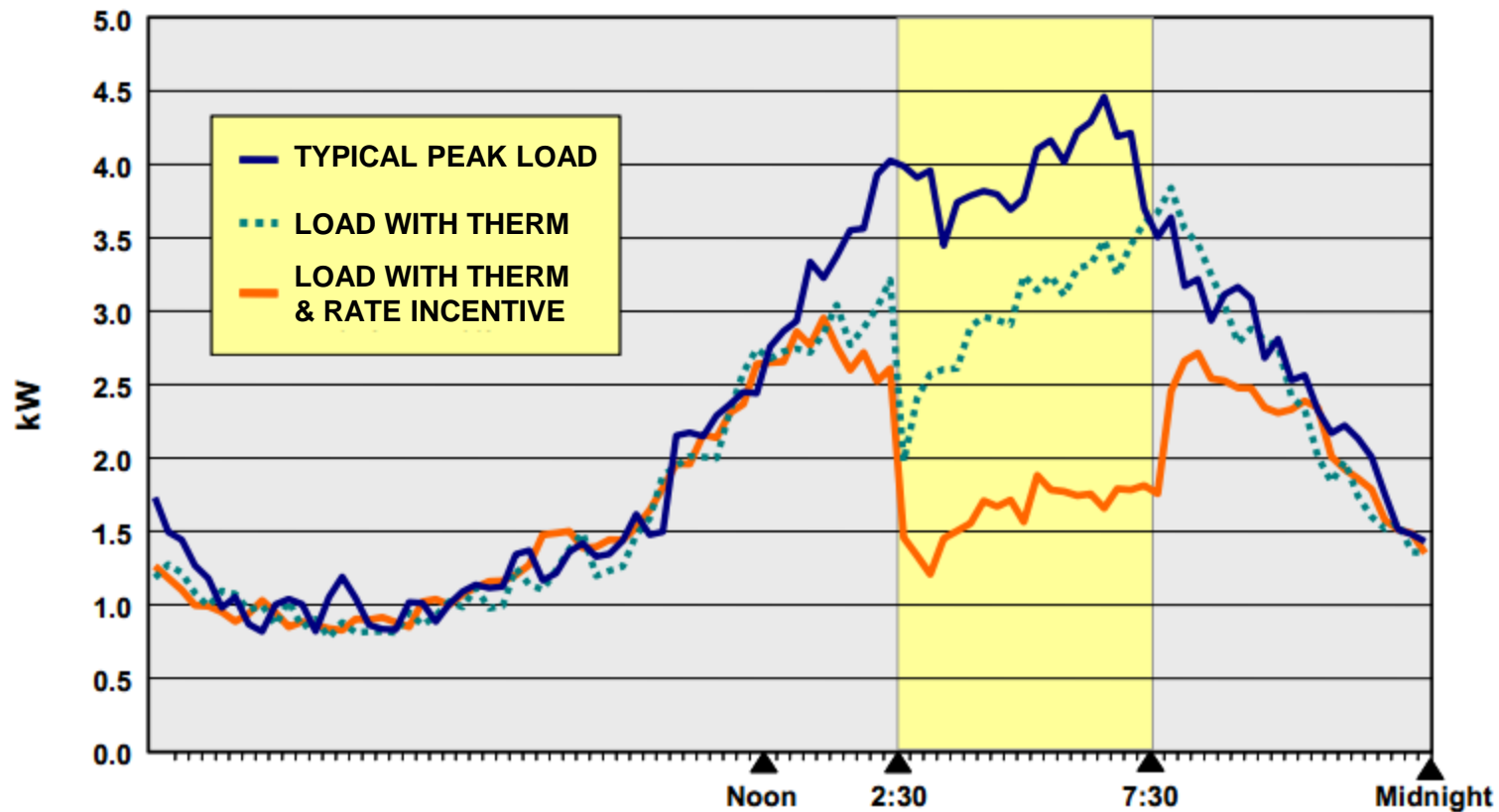


SOURCE: NIST Smart Meter Framework 1.0 Sept 2009

NIST – NATIONAL INSTITUTE OF STANDARDS

SMART GRID OVERVIEW

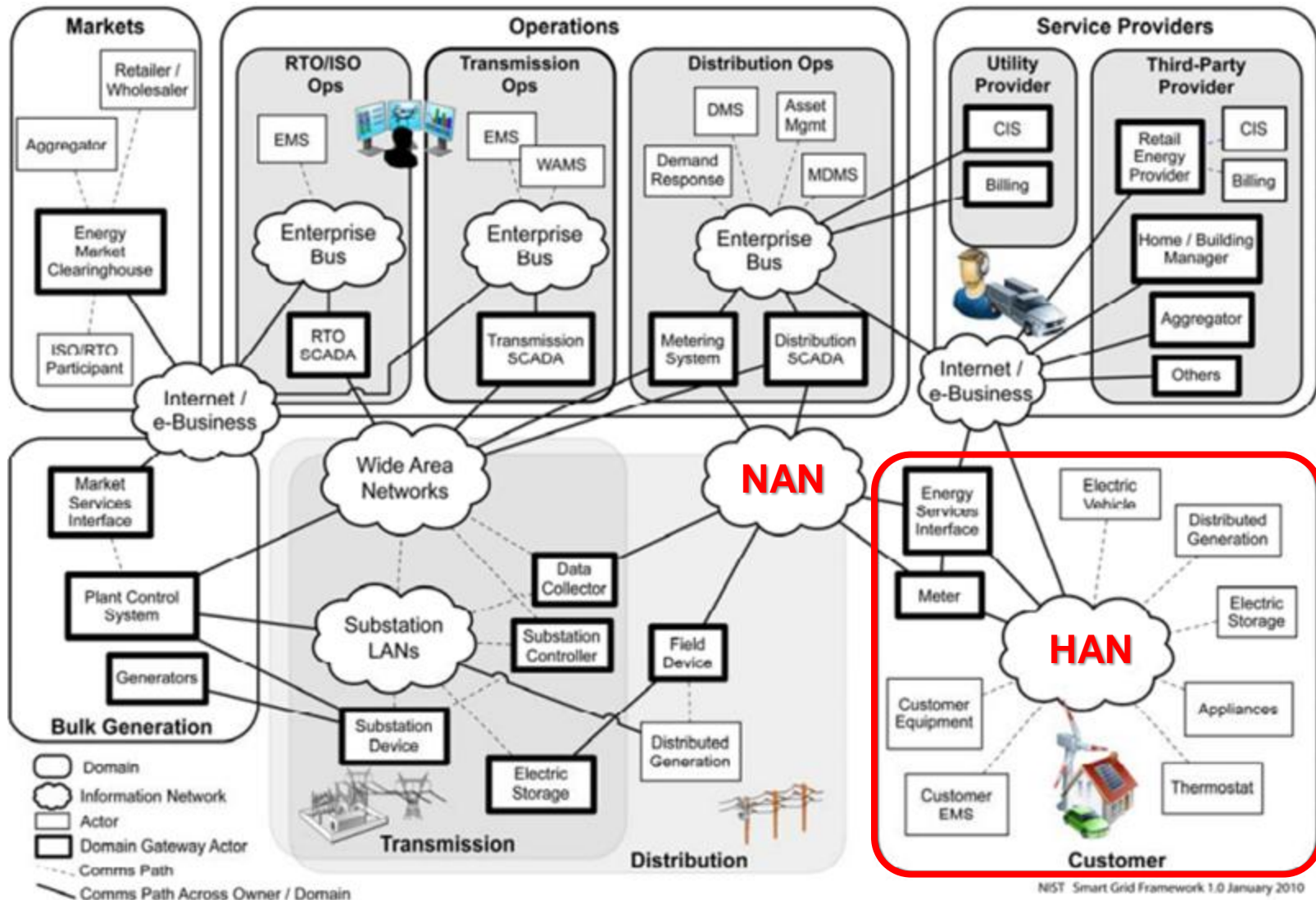
DEMAND RESPONSE



SOURCE: Edison Foundation

SMART GRID OVERVIEW

SMART GRID REFERENCE ARCHITECTURE



SOURCE: NIST Smart Meter Framework 1.0 Sept 2009

SMART GRID OVERVIEW

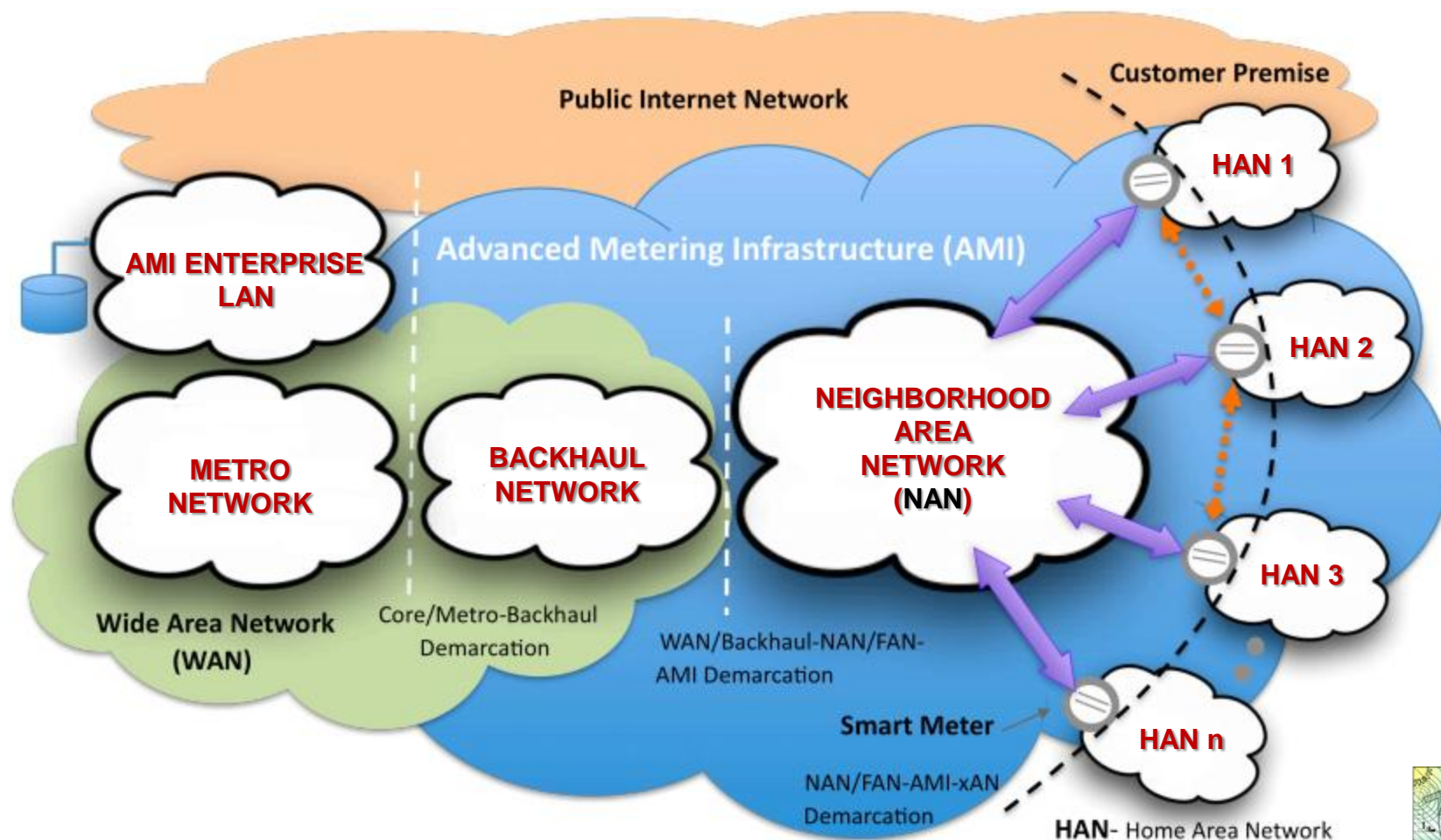
SMART GRID INDUSTRY ECO-SYSTEM



SOURCE: Andres Carvallo, *The Advanced Smart Grid*

SMART GRID ARCHITECTURE

ADVANCED METERING INFRASTRUCTURE (AMI) REFERENCE MODEL



SOURCE: Smart Grid Communications architectural Framework, Sonoma Innovation



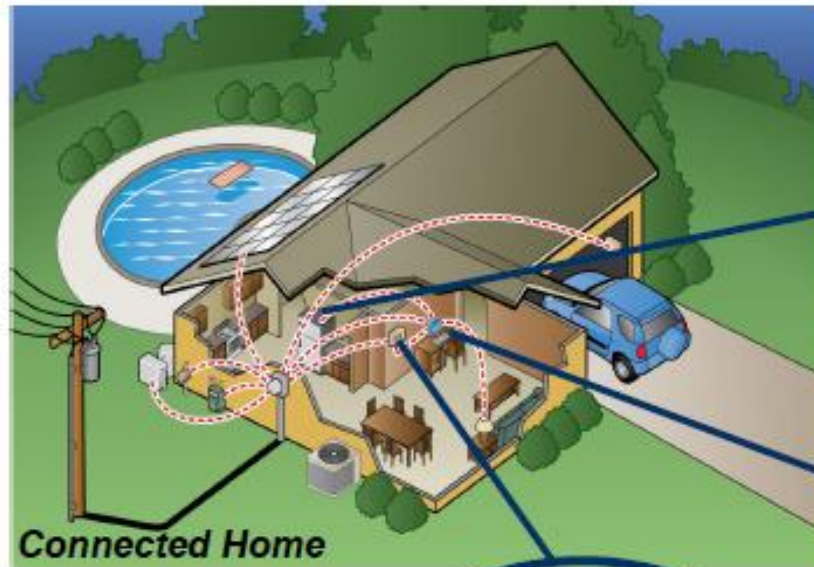
SMART METERS

NEIGHBORHOOD AREA NETWORK (NAN)



SMART GRID ARCHITECTURE

HOME AREA NETWORK (HAN)

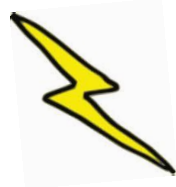


SMART GRID ARCHITECTURE

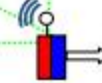
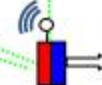
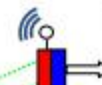
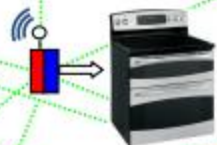
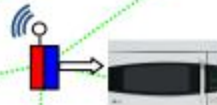
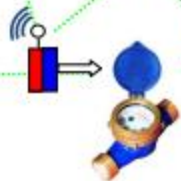
HOME AREA NETWORK (HAN)

- GE Home-to-Grid Demand Response Solution
- 12 Zigbee Transmitters @ 60 mW each
- Enables Demand Response

NAN



Home Energy Manager



imagination at work

SOURCE: GE Demand Response Enabled Appliances/Home Energy Management System

SMART METERS

SMART METER TYPES



ELECTRIC POWER
WATER
GAS

ANALOG METER



SMART METER



**SINGLE
FAMILY
DWELLING**



**MULTI
FAMILY
DWELLING**



**COMMERCIAL
SMART METER**



**RESIDENTIAL
SMART METER**



A device that measures & registers the integral of the electrical quantity with respect to time.

SMART METERS

HISTORY OF METERING

✓ **History**

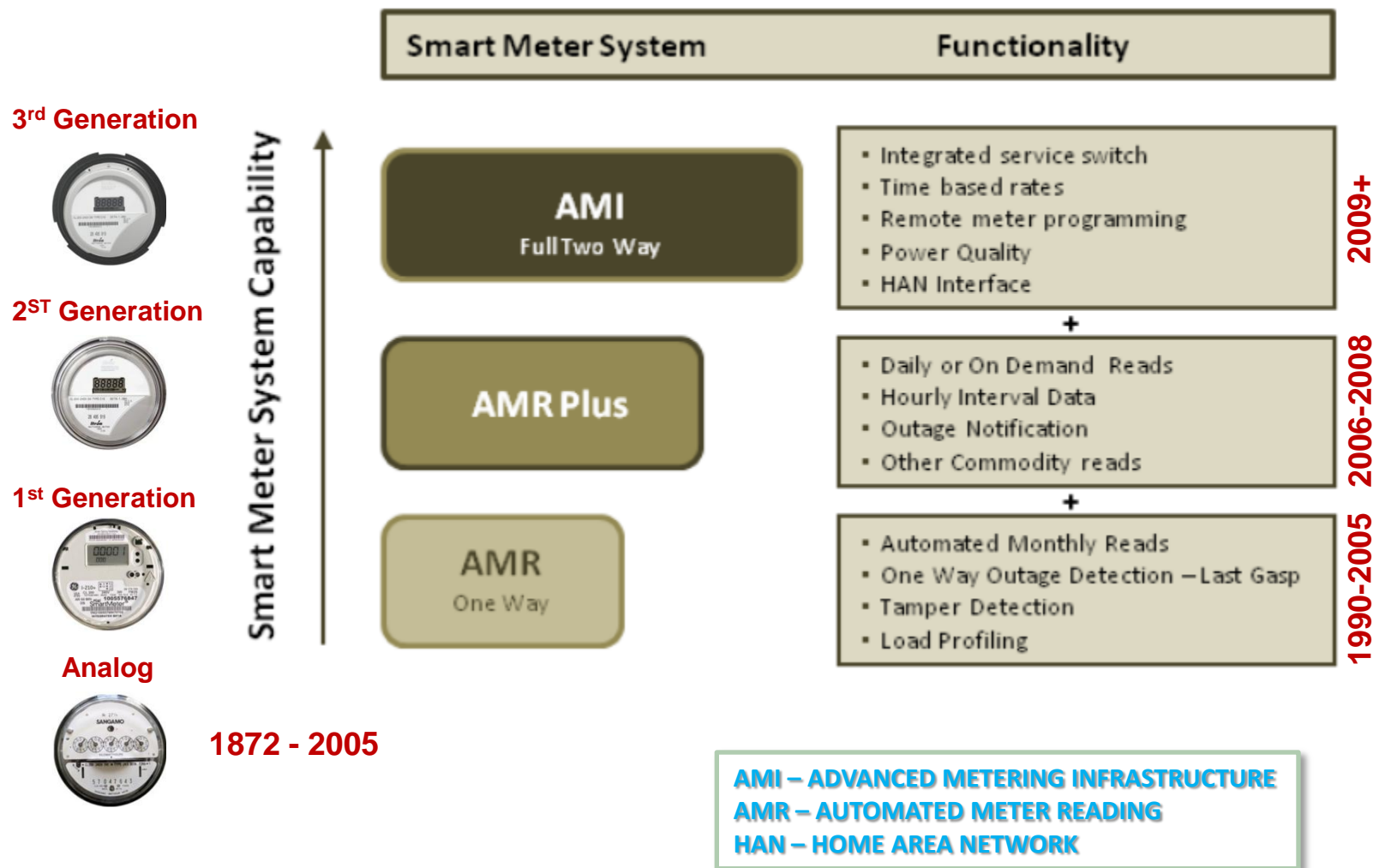
- **1851** 1st Gas Meter
- **1872** Electric Meter Invented
- **1889** 1st “Spinning Disk” Power Meter
- **1980s** Solid State/Digital Meters
- **1990s** 1st AMR
- **2009** Smart Meters w/ 2-way Communications

✓ **Evolution**

- Mechanical
- Electromechanical
- Electronic

SMART METERS

SMART METER TECHNOLOGY EVOLUTION



***SOURCE:** ¹ EEI-AEIC-UTC White Paper - A Discussion of Smart Meters And RF Exposure Issues

SMART METERS

✓ **Landis+Gyr** 26%



✓ **Itron** 24%



✓ **Sensus** 21%



✓ **GE Energy** 20%



✓ **Elster** 5%



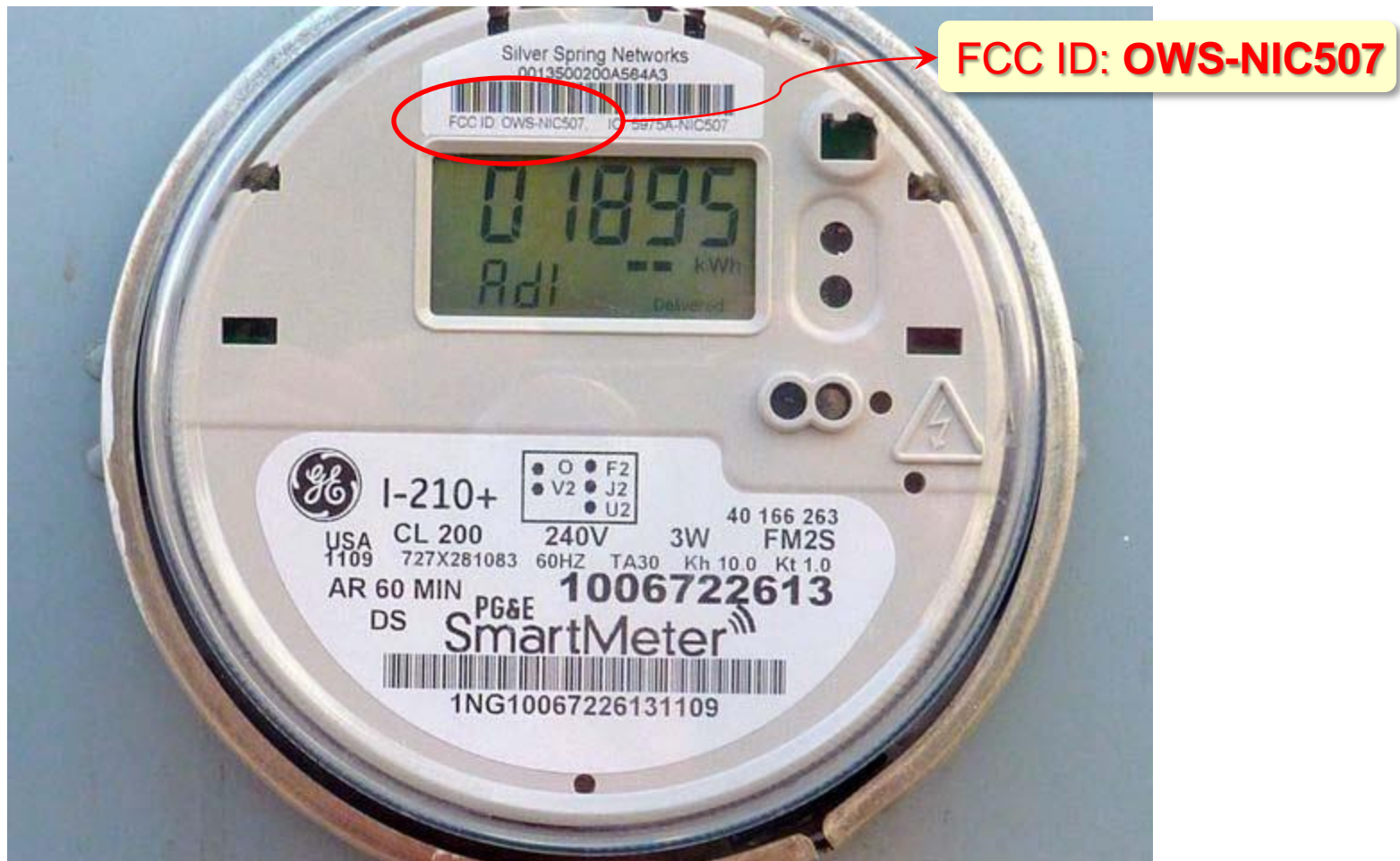
✓ **Echelon** 3%



SOURCE: Pike Research

SMART METERS

FCC IDENTIFIER



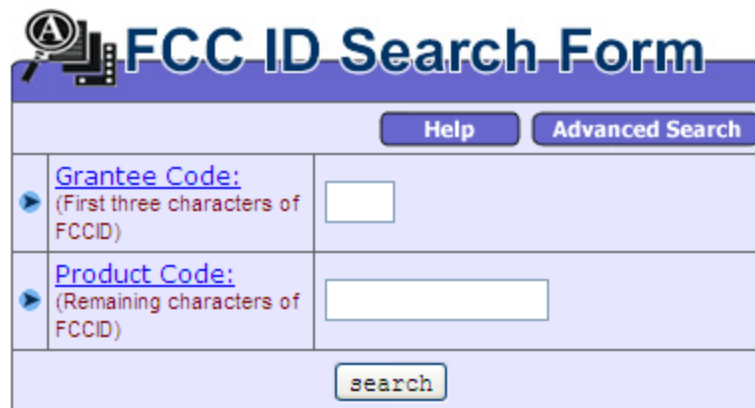
<http://transition.fcc.gov/oet/ea/fccid/>

SMART METERS

FCC IDENTIFIER

✓ **FCC ID**

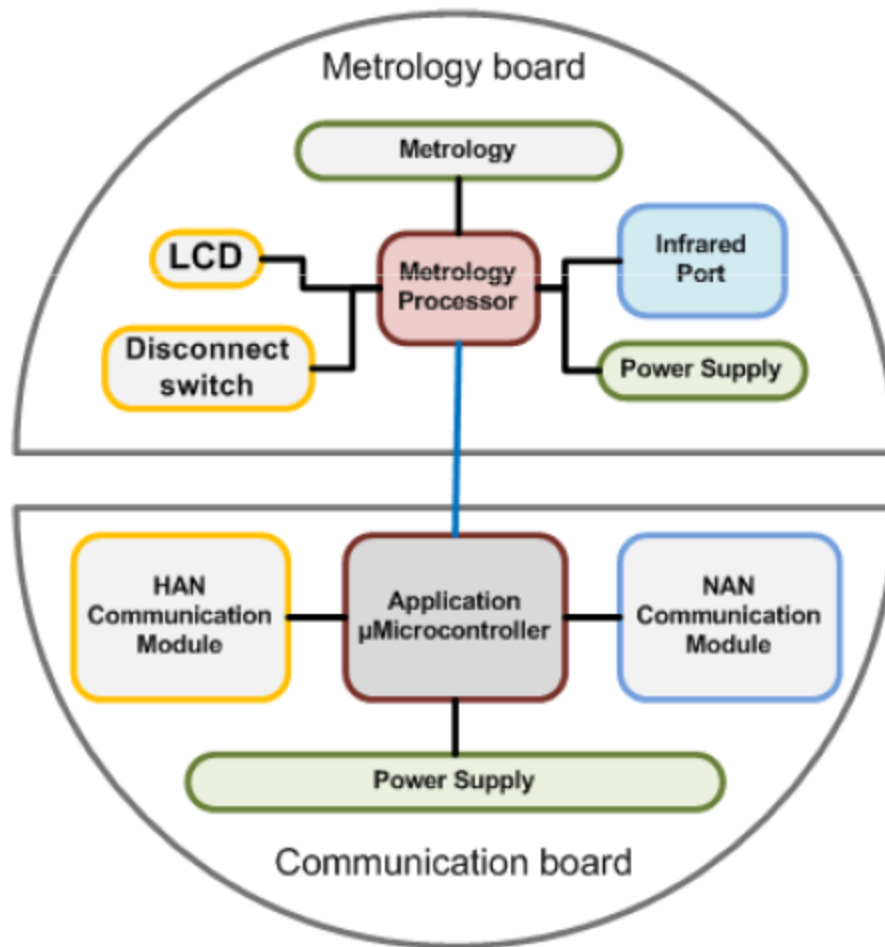
- Smart Meters should have an **FCC ID** number which uniquely identifies the transmitter(s) parameters & exposures levels
- Typical FCC ID: **SK9AMI-2A**
 - **Grantee Code:** SK9 **Product Code:** AMI-2A
- Go to the **FCC identification database** at <http://transition.fcc.gov/oet/ea/fccid/>



The image shows a screenshot of the FCC ID Search Form. At the top, there is a magnifying glass icon and the title "FCC ID Search Form". Below the title, there are two buttons: "Help" and "Advanced Search". The form is divided into two main sections for input. The first section is labeled "Grantee Code:" with a subtext "(First three characters of FCCID)" and a text input field. The second section is labeled "Product Code:" with a subtext "(Remaining characters of FCCID)" and a text input field. At the bottom of the form, there is a "search" button.

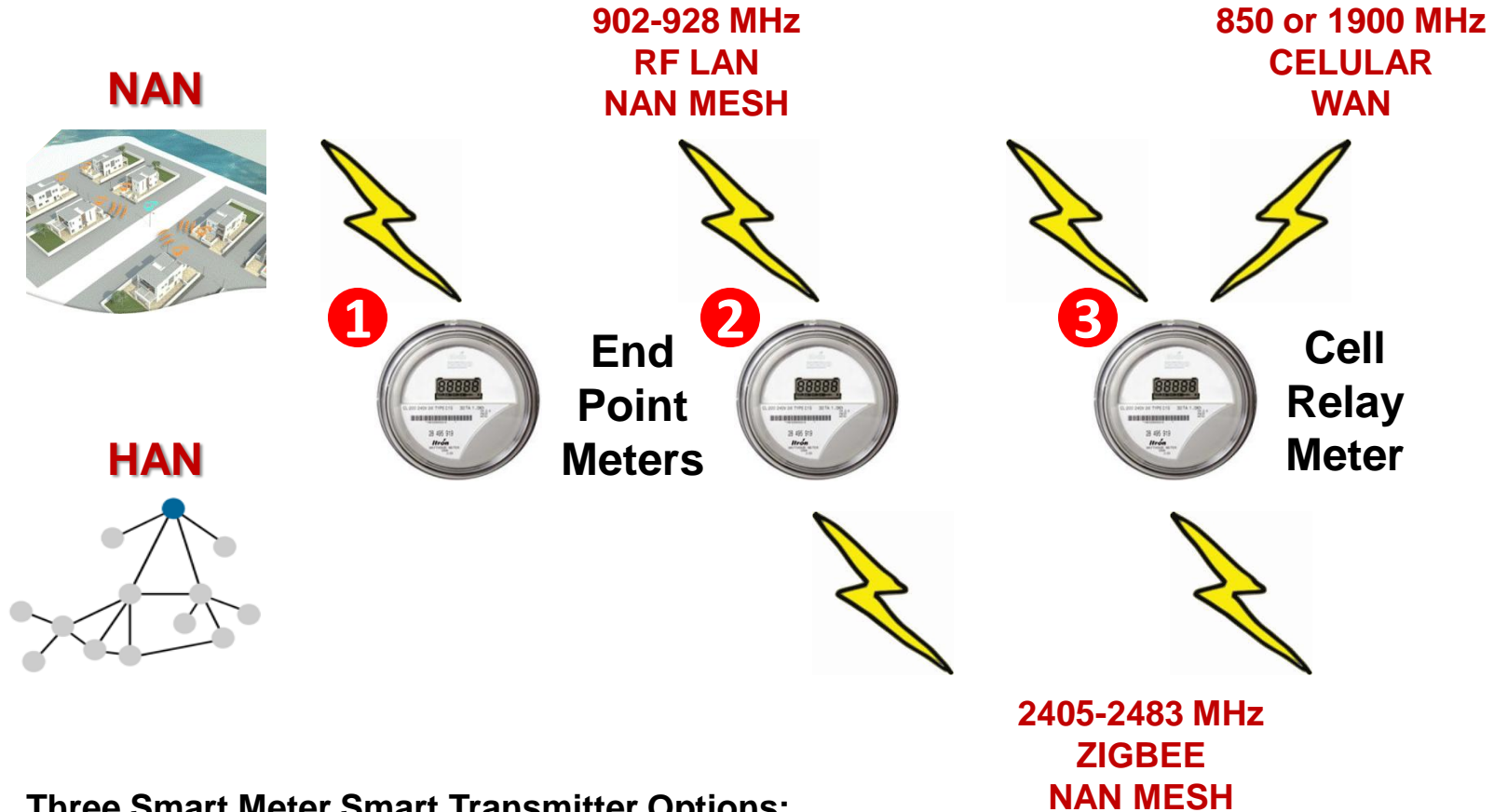
SMART METERS

BLOCK DIAGRAM



SMART METERS

TRANSMITTER OPTIONS



- ✓ Three Smart Meter Smart Transmitter Options:
 1. **NAN** Only End Point
 2. **NAN** + **HAN** End Point
 3. **NAN** + **WAN** + **HAN** Cell Relay
- ✓ Up to two Transmitters can Simultaneously Transmit
- ✓ Total Exposure = Σ Transmitters = **NAN** + **WAN** + **HAN**

HAN
NAN
WAN

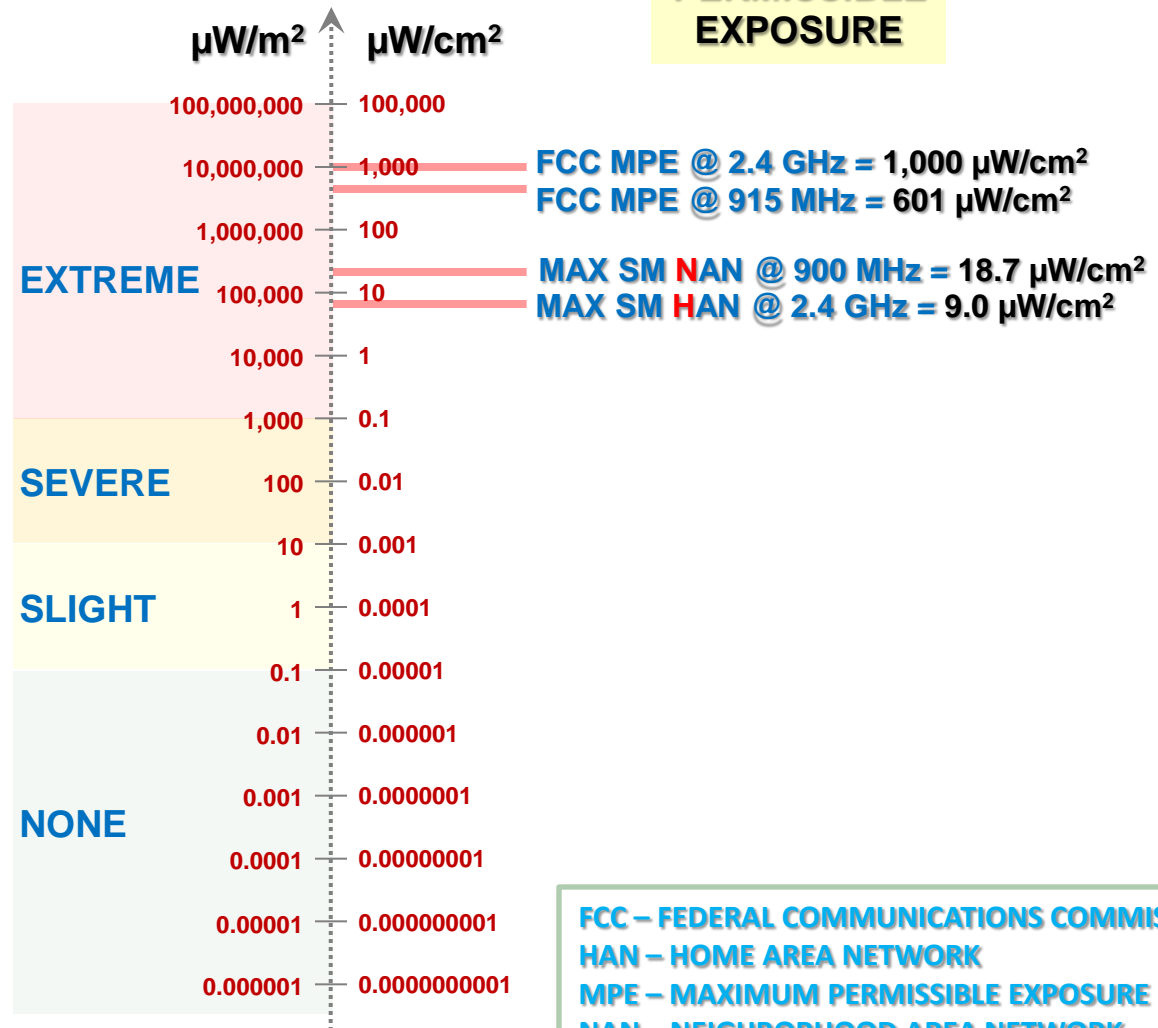
HOME AREA NETWORK
NEIGHBORHOOD AREA NETWORK
WIDE AREA NETWORK

SMART METER EXPOSURE LEVELS

BUILDING BIOLOGY EXPOSURE LIMITS

- ✓ Smart Meters Exceed Building Biology Exposure Limits
- ✓ Transmit in 2.4 GHz & 900 MHz bands – **SIMULTANEOUSLY**
- ✓ Total Exposure = Σ Transmitters

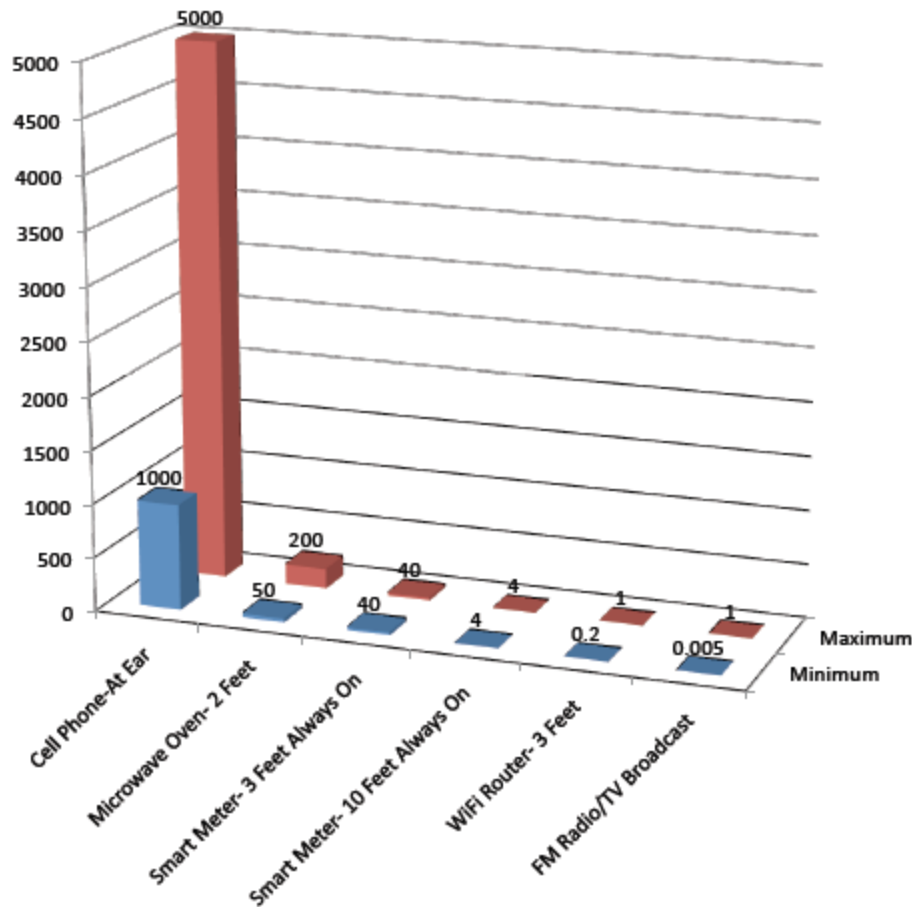
FCC MAXIMUM PERMISSIBLE EXPOSURE



FCC – FEDERAL COMMUNICATIONS COMMISSION
 HAN – HOME AREA NETWORK
 MPE – MAXIMUM PERMISSIBLE EXPOSURE
 NAN – NEIGHBORHOOD AREA NETWORK

SMART METER EXPOSURE LEVELS

California Council on Science
and Technology (CCST)



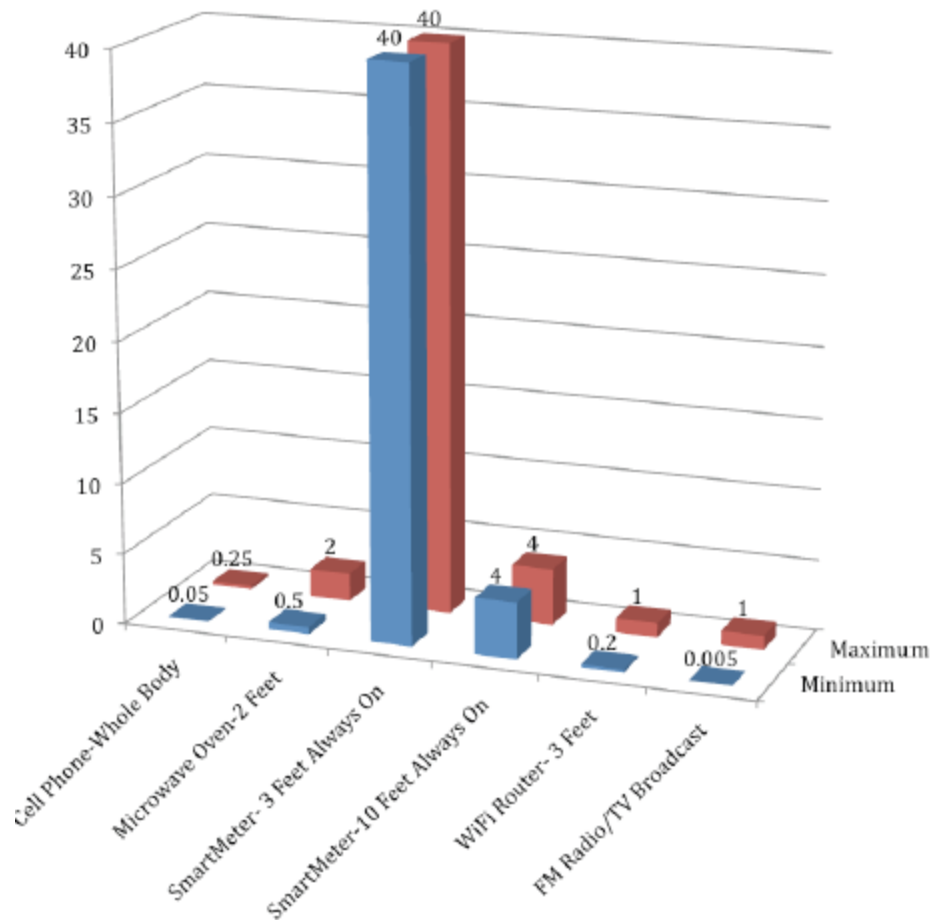
**Cumulative whole
body exposure of
Smart Meters is two
orders of magnitude
less than a cell
phone.**

SOURCE: California Council on Science and Technology, "Health Impacts of Radio Frequency from Smart Meters", 31 January 2011

SMART METER EXPOSURE LEVELS

California Council on Science
and Technology (CCST)

*After correcting for duty cycle and
dissimilar units....*



**Cumulative whole
body exposure of
Smart Meters is two
orders of magnitude
higher than cell
phones.**

SOURCE: Daniel Hirsch, Comments on the Draft Report by the California Council on Science and Technology
“Health Impacts of Radio Frequency from Smart Meters”, 31 January 2011

SMART METER EXPOSURE LEVELS

“SECOND-HAND” RADIATION MAP IN SALT LAKE CITY, UTAH



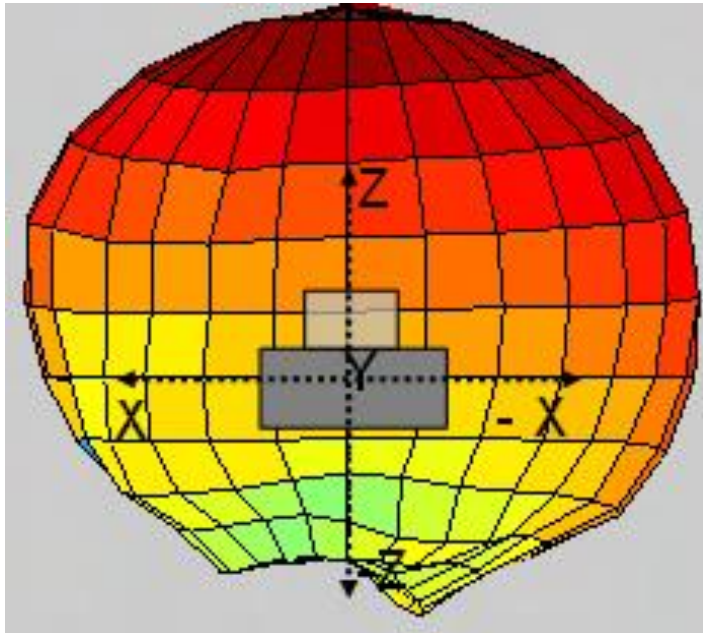
Smart Meter Deployments are Significantly Increasing Electromog

SOURCE: “Second-hand” microwave geography in Salt Lake City, Utah, Paul M. Torrens, Geography, Arizona State University

SMART METER RF FIELD MEASUREMENTS

SMART METER WAVE PATTERN

top view



SMART METER
RF WAVEFORMS
ARE SPHERICAL

RF SIGNAL METER *with omnidirectional antenna*



1. FCC ID?
2. Location of meter
3. Location of neighbors meters
4. Signal strength in sleeping areas
5. Determine if shielding is an option

SMART METER MITIGATION

- ✓ **Smart Meter Opt-Out**
 - Difficult, costly, neighbors
- ✓ **Relocate Meter**
 - Costly, neighbors
- ✓ **Distance**
- ✓ **Shielding**
 - Can be effective
- ✓ **Hardwire - NAN & HAN**
 - Long term solution
 - Every home has copper pairs
 - Fiber optics is best

IBE 312 DISCUSSES RF MITIGATION IN DETAIL

SMART METER MITIGATION

SHIELDING MATERIALS

Inner Wall Shielding
13 - 23 dB Attenuation



Bed Shielding Canopies
10 – 44 dB



Shielding Kits



Microwave Shielding Fabric
10 - 44 dB Attenuation



Shielding Paint
35 dB Attenuation



Shielding Window Foil
14 - 33 dB Attenuation



SMART METER ISSUES



- ✓ **Proliferation of RF**
- ✓ **Dirty Power**
- ✓ **Privacy Concerns**

SMART METER ISSUES

✓ Proliferation of RF

- 1 billion Smart Meters worldwide by 2020²
- 65 million Smart Meters in US by 2020
 - 50% Penetration of all US households
 - Push for ubiquity (100% Penetration)
- Equivalent to 22% Increase in Cellular Links
 - Based on 302.9M US subscribers in 2010¹
- Multiple Transmitters per **Smart Meter**
- Multiple Transmitters per **Home Area Network (HAN)**
 - Smart Appliance Market: \$3B to \$15B by 2015²
- Transmitters from **Neighborhood Area Networks (NAN)**

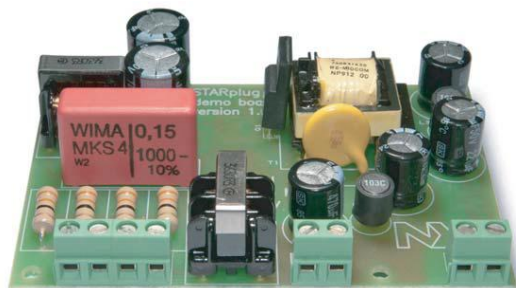
WIRELESS IS THE ENABLING TECHNOLOGY FOR THE SMART GRID

SOURCES: ¹ CTIA, ² Zpryme

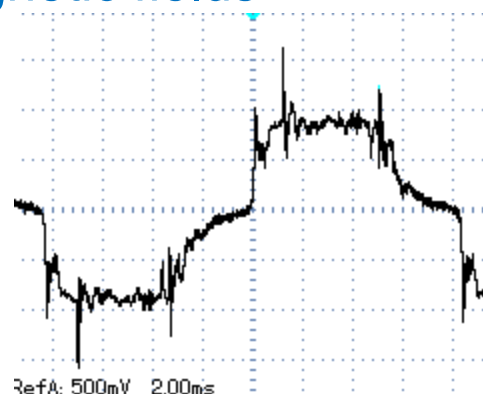
SMART METER ISSUES

✓ Dirty Power

- Switched Mode Power Supplies (SMPS)
 - Provide AC-to-DC to power conversion for smart meter electronics
 - Distortion of power mains caused by switching regulator
 - Inrush current at the inputs results in “transients” in the form of harmonic distortion and noise
 - The home AC wiring serves as an antenna to propagate these irregularities as electric or magnetic fields



STARplug SMPS

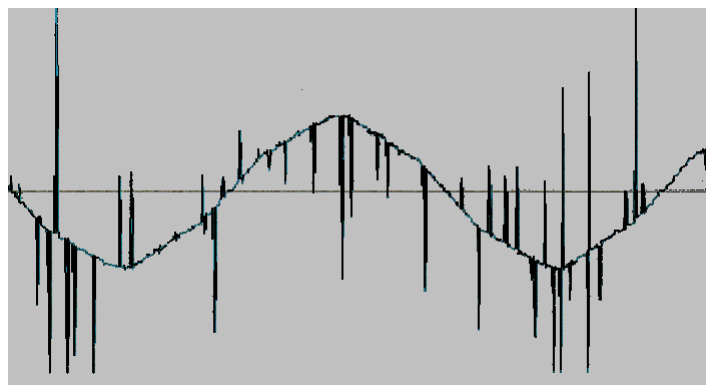


SOURCE: Waveform image courtesy of Rob States, “Power Transient Measurements”

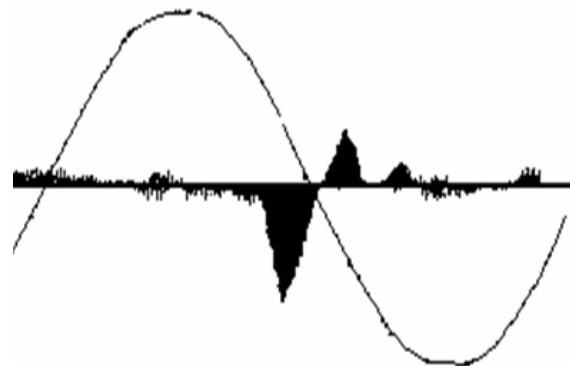
SMART METER ISSUES

✓ Dirty Power

- Power Line Communications (**PLC**)/Broadband-over-Power Line (**BPL**)
 - Anything external source that disturbs the pure sinusoidal waveform of the power mains is undesirable
 - As with SMPS' these incessant signals induce electric and magnetic fields



Noise Spike on AC Lines



Modulated Data on AC Lines

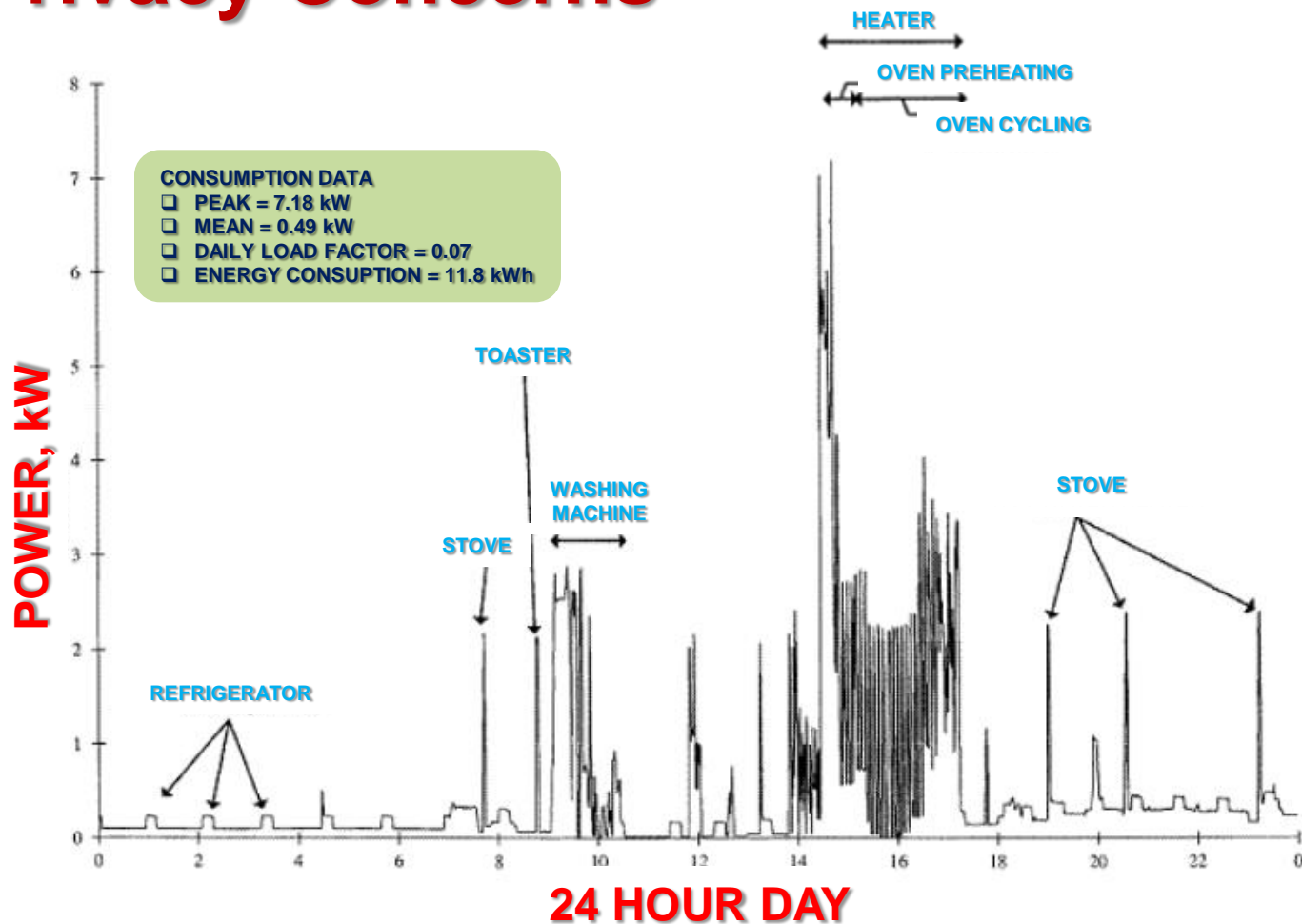
SOURCE:

✓ Privacy Concerns

- A Smart Meter is a stethoscope into our home
- Intimate & detailed information about appliance use, residency & profiled behavior patterns
- Commoditization of usage data
 - Last industry not to sell information on its customers
- Utility company control of appliances
 - Peak Load Management
- Nonintrusive Appliance Load Monitoring (**NALM**)
 - Energy Consumption Prediction using Voltage & Current Changes
 - Example application that threatens our privacy
- Industry very resistant to Opt-Out

SMART METER ISSUES

✓ Privacy Concerns



SOURCE: NIST

SUMMARY

- **The proliferation of RF will continue to ramp**
- **RF is migrating closer and closer into our personal space**
- **HANs are likely to exceed even the FCC MPE levels, especially when combined with other home wireless technologies**
- **Smart Meters are programmable devices with an industry seeking to develop new applications that are likely to go viral**

SUMMARY

- **Our private information will be commoditized and sold**
- **We are turning our homes and communities in large microwave ovens**
- **We are participants in the largest biological experiment on the planet without our consent**

THANK YOU



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