Enabling Load Management (LM) Technologies and Communications Context

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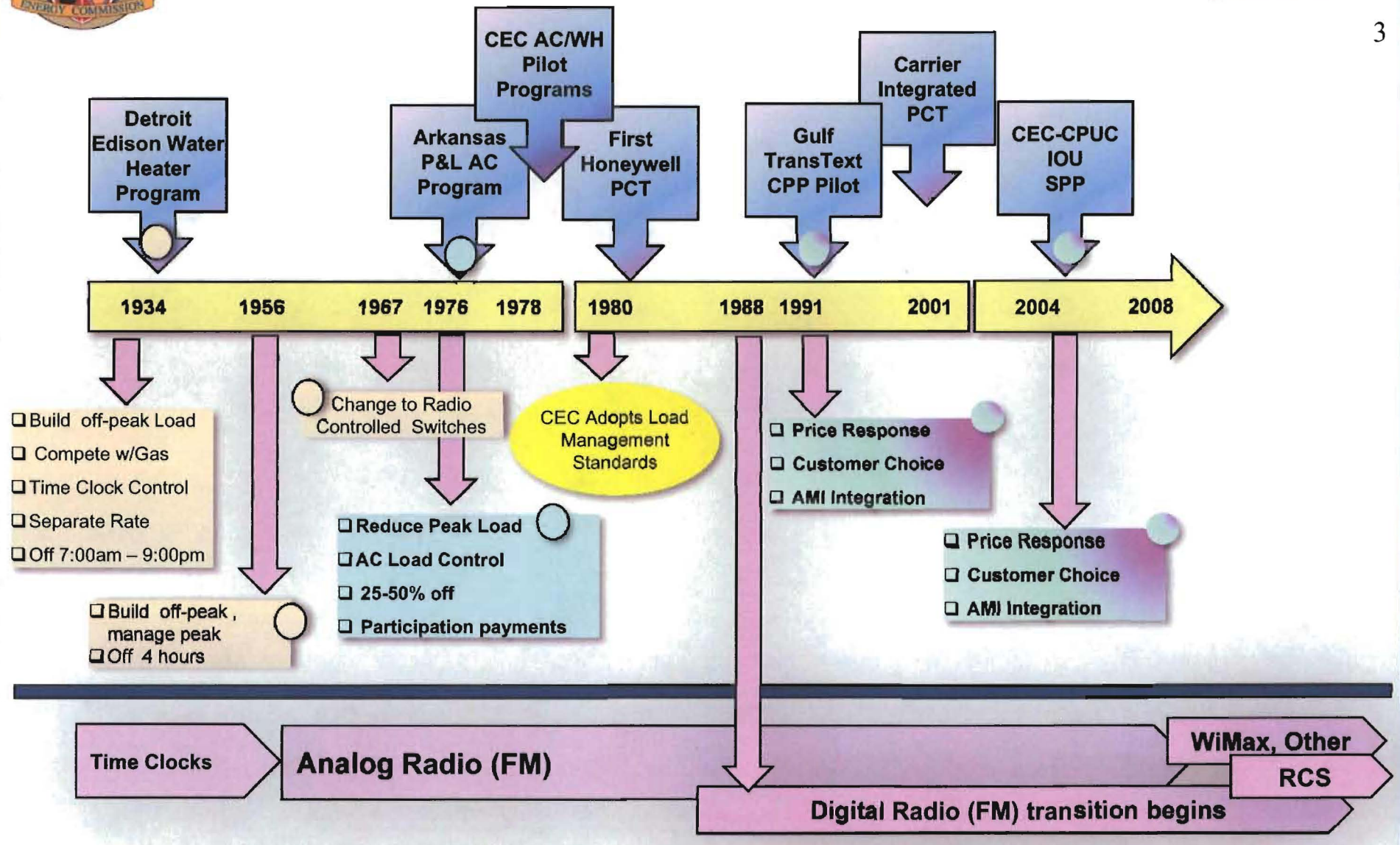
Purpose

- Provide a framework for understanding past, present & future enabling LM technologies and communications systems
- Review the proposed AutoDR standard and PCT reference design
- Glimpse future technologies that will cost-reduce LM devices & systems

Evolution of DR – Technology & Programs



Analog to Digital

- Roger's slide highlights the transition from analog to digital control technologies
- The primary difference between these two control technologies is the information processing element, i.e., the micro-processor (µp) which facilitates
  - customer choice
  - technology upgrades
  - standards that lead to lower costs

Digital Control Devices

- **Computational platform similar to a PC platform but with different input/output (I/O), storage & computational power (µp)**
  - Instead of a keyboard (I), mouse (I) and monitor (O), a control device might have a keypad (I), a joy stick (I) and an LCD (O)
  - Instead of dealing large files (Word, Excel), it converts small streams of data to information, which it can store, share with another control device, send to a remote display (TV monitor)

Digital Control Devices (con't)

- Instead of a camera (I), CD drive (I+O) and printer (O), it has sensors (I), SD card (I+O) and actuators (O)

- **The computational platform can support the same array of communications as the PC platform and is only limited by the µp's power and its storage capacity. It can also be part of a network which includes PCs, other control devices, cell phones, etc.**
- **Processes information like the PC**

Customer Choice

All signals in & out of a true digital device (PC-like computational platform) must go through the up. This means that the user of the device always has multiple ways of being in control. A digital control can be always be designed to respond to user-initiated commands (e.g., override) that come from I/O including communications. Analog control devices typically require fixed pre-configured options.

Technology Upgrades

The digital control device can be thought of as an information processing platform that can be adaptive (and cost-effective) over the life of the hardware. The digital control platform can be designed to preserve its value through software upgrades and extend its capability through expansion port add-ons similar to the way a PC and cell phone do.

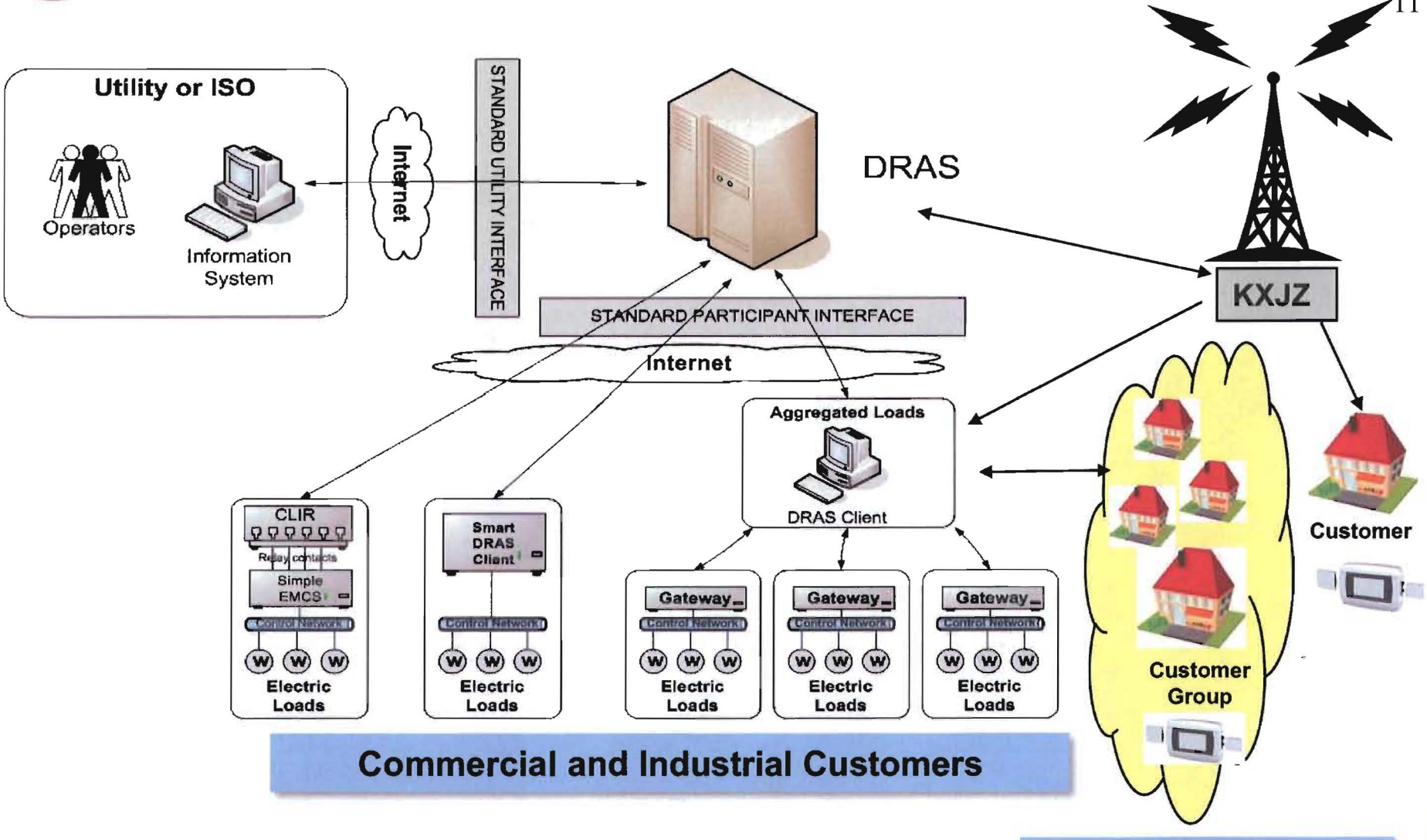
Standards/Low Costs

- **Using the digital PC-like control platform paradigm, it's easier to understand the information exchange standards**
  - Regulators define the functionally they want (e.g., price-responsive LM devices) and let the vendors and IOUs define standards that meet the needs of a wide spectrum of customers
- **The regulators define functions (WHAT)**
- **The vendors define products (HOW)**

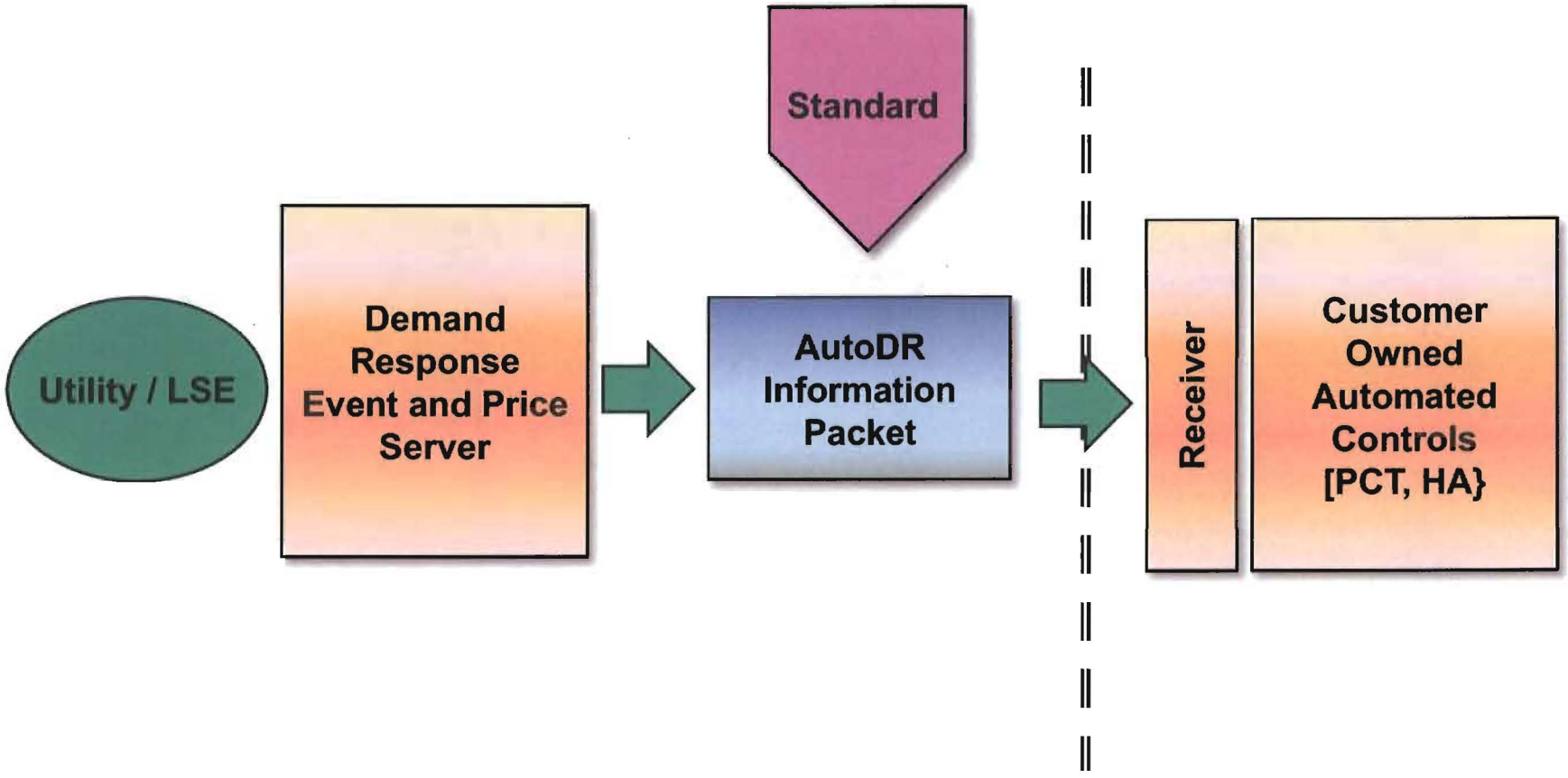
PIER-funded Initiatives

- **Enabling Technologies & Communications**
  - AutoDR for large C&I (>200 kW) loads; assumes Internet signal delivery, some central point of control (EMS on a network or dry contacts wired to loads), and the ability to preprogram shed strategies.
  - Several signal delivery methods for residential and light commercial (<200 kW) loads; assumes multiple communication delivery methods -- 1-way broadcast, 2-way narrowband bursty & 2-way broadband with support for a standard information model for all methods including AutoDR via translation.

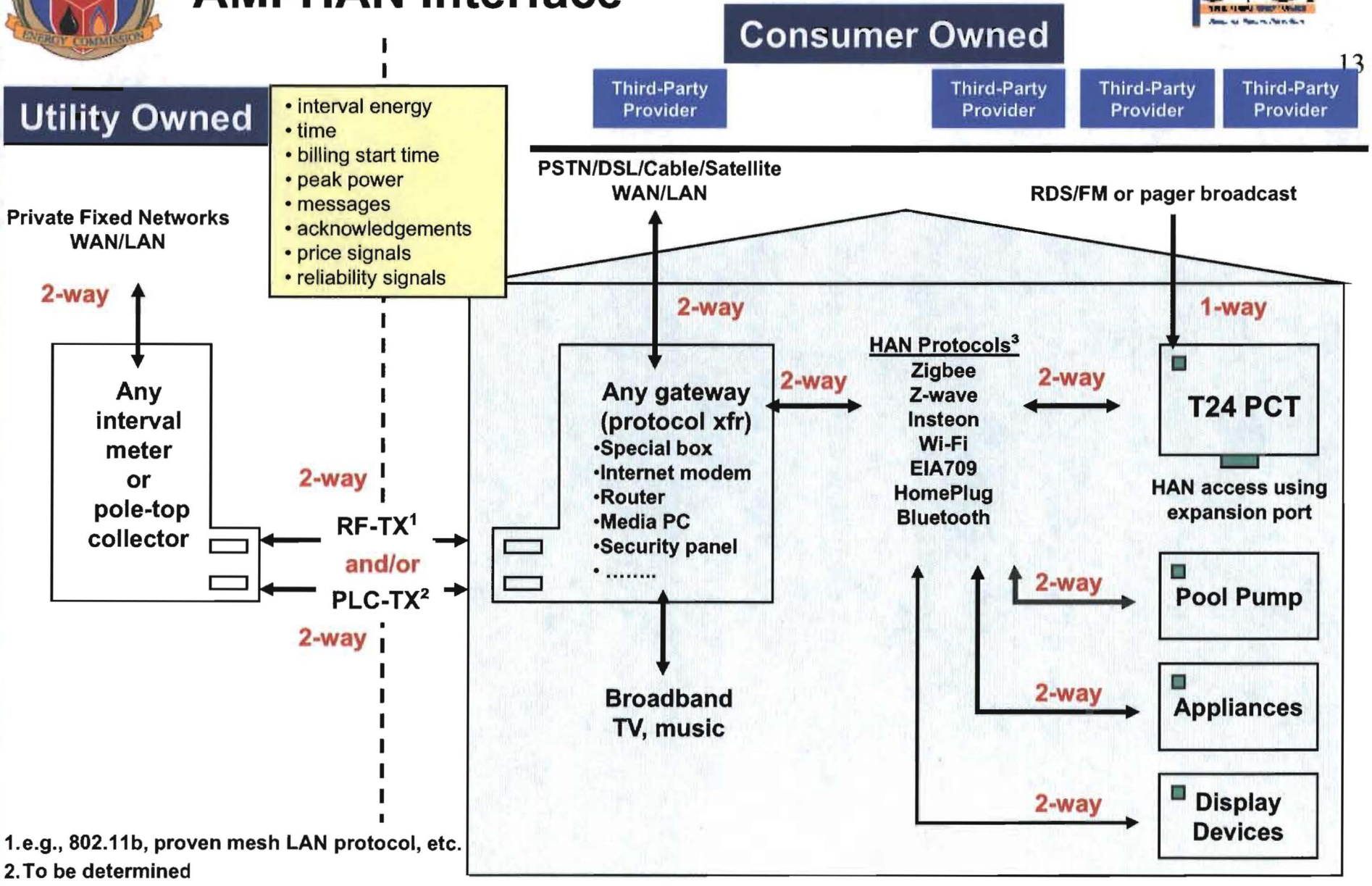
AutoDR Automation Server and Client



Information Flow



AMI-HAN Interface



1. e.g., 802.11b, proven mesh LAN protocol, etc.
2. To be determined
3. Up to 45 active protocols worldwide

Proposed LM Standards

- **Title 24**
  - Global temperature reset for C&I EMCS
- **AutoDR (Open ADR standard)**
  - ASHRAE
  - NIST
- **PCT Reference Design**
  - Title 24
  - OpenHAN

Today's Technology

- Most 16- & 32-bit µp's are capable enough for LM applications, are reasonably priced and have event-driven real-time operating systems (RTOS)
- Voltage and current sensors elements (for real-time energy and power) are still too large & costly to be widely integrated into appliances and plug loads

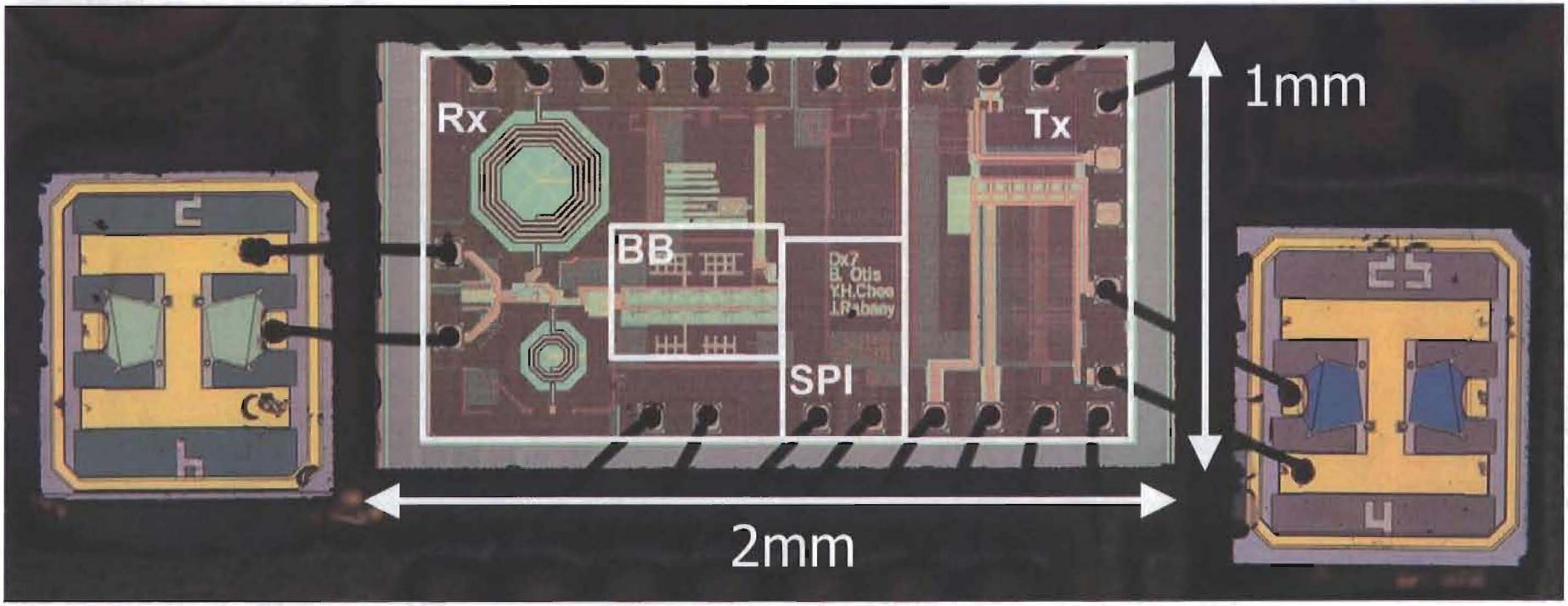
Today's Technology (con't)

- Batteries are getting better – up to 10-year life for very low duty-cycle applications
- 2-way narrowband bursty mesh-network transceivers based on IEEE 802.15.4 physical and data-link layer standards are low cost & require ~100 mW ave. power
- 2-way broadband Wi-Fi point-to-point communications are attaining low power status similar to 802.15.4

Tomorrow's Technology

- Future µp's will include integrated radios, sensors & power supplies
- Silicon 2-way narrowband mesh-network radios are now at ~100 µW

Fully Integrated 1mm³ Rx/Tx



- No external components (inductors, crystals, capacitors)
- 400µW from 1V in 0.13µm CMOS
- Very small implementation volume

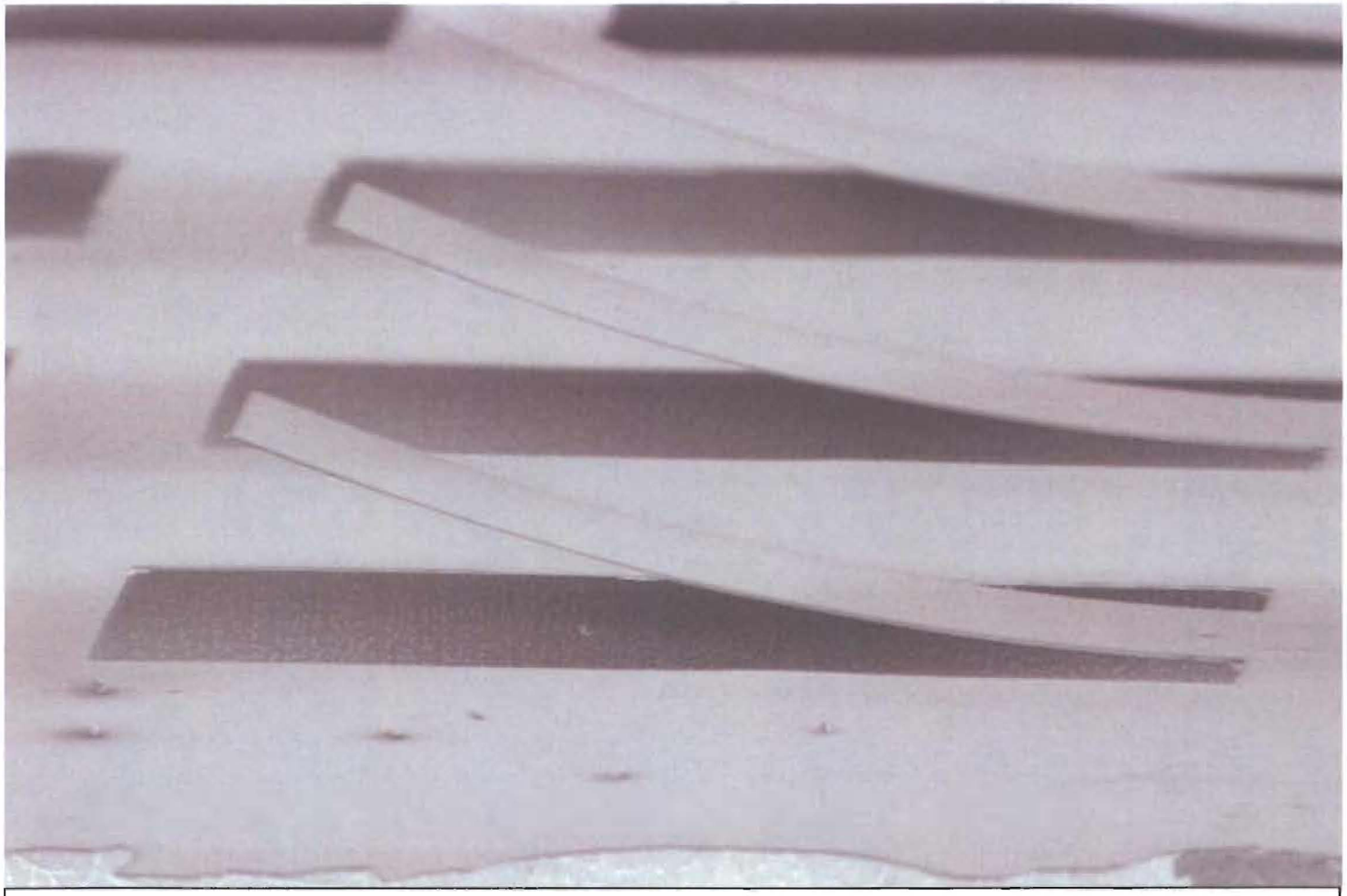
Presented at ISSCC 2005

B. Otis, Y.H. Chee

Tomorrow's Technology (con't)

- MEMS (Micro-Electro-Mechanical Systems) voltage & current sensors being developed at UC Berkeley are putting these sensors in silicon
- MEMS energy scavengers will work with ink-jet printable batteries and capacitors to allow integrated power supplies that can last 25-50 years

MEMS Cantilevers



Summary

- Technology is available and is getting better and less expensive
- WHAT regulators want can leverage standard digital paradigms
- HOW vendors & utilities meet these functional requirements will leverage information exchange standards

Backup Slides

What is AMI

- **Advanced Metering Infrastructure**
  - Interval meters that can record usage on an hourly basis
  - Communication infrastructure that retrieve the hourly usage and send price and emergency signals to the home
  - Back-office software that processes hourly usage and bills the customer accordingly

Analog vs. Digital Signals

- An analog signal uses some property of the medium to convey the signal's content and is historically achieved and retrieved using a transducer not a micro-processer
- A digital signal is a quantized discrete-time signal; a discrete-time signal is a sampled analog signal using a micro-processor