Electronics, Networks and Energy Use in Buildings

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Overview

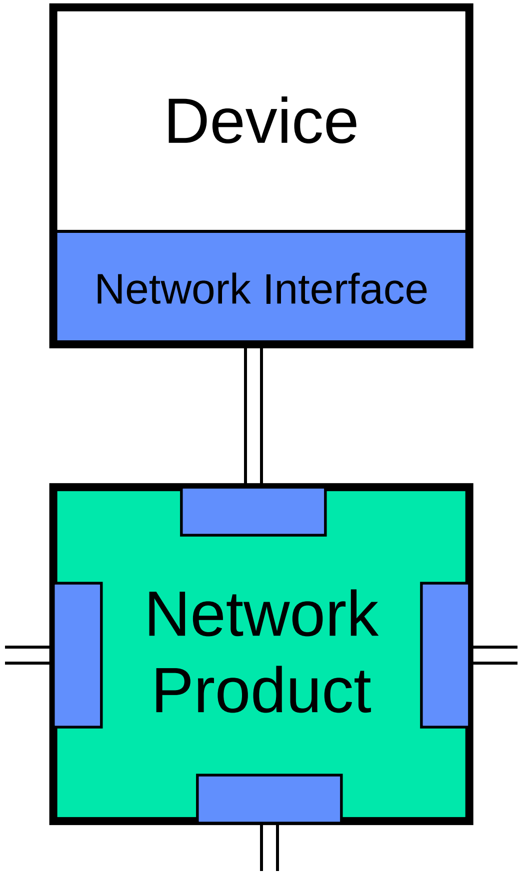
- Background on LBNL electronics research
- Ways electronics affect energy use in buildings
  - Direct
  - Indirect
- Research and policy agenda for networks and buildings

LBNL Research on Electronics and Networks

- LBNL has been researching energy efficiency in buildings for 35 years (technologies and policies)
- Interest in electronics grew out of efforts to forecast energy use in buildings
  - “Miscellaneous” end-use growing 2-3x faster than others
  - Proliferation of IT and consumer electronics key to growth
- Increased focus on electronics energy use
  - Technical support to EPA ENERGY STAR
  - Energy use in low-power modes
  - Growing realization that networks are important driver of electronics energy use
    - Energy Efficient Digital Networks

Electronics Affect Buildings Energy Use

- Direct
  - Electronic devices (IT, consumer electronics, data centers, network equipment)
- Indirect (via network)
  - Induced energy use in networked devices
  - Influence energy-related decisions
  - Digital networks for building control



Direct Energy Use of Electronics

- Electronics <u>are</u> an end use of electricity
  - *"Devices whose primary function is Information (obtain, store, manage, present)"*
  - Includes both Information Technology (IT) and Consumer Electronics (CE)
  - Much of this digitally networked already
- Electronics consumption in U.S. at least 250 TWh/year <u>and rising</u>
  - ~7% of all U.S. electricity consumption
  - 2/3 of future building-sector electricity growth is due to electronics and "other" (source: EIA AEO 2007)
- Increasingly well understood and addressed by policies

ENERGY STAR Product Labeling

- Started with IT equipment and currently covers many IT and CE products
  - PCs, monitors, imaging equipment
  - TVs, Set-top boxes, DVD/VCR, home audio, cordless phones
  - External power supplies, battery chargers
- New products
  - Enterprise servers
- Considering enterprise storage equipment and network equipment
- Growing importance of network connections

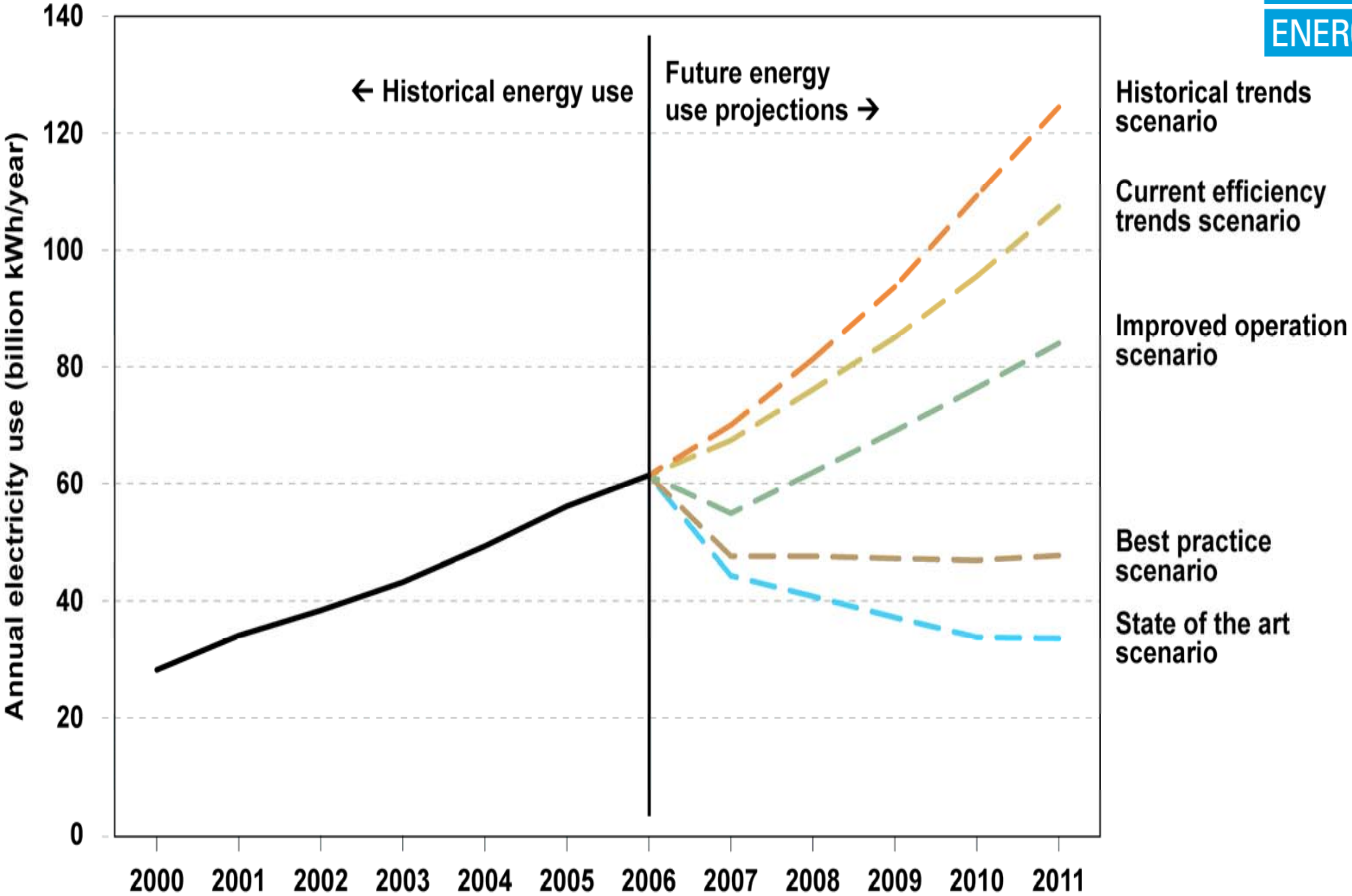
Ongoing Developments with IT Products

- Computers
  - Version 4.0: addresses idle and low-power modes, include internal power supply efficiency
  - Version 5.0: develop a holistic approach to computer efficiency (performance benchmark), reward network presence when asleep
- Imaging equipment: Tier 2 requires lower sleep power and annual kWh ("TEC") levels
- Monitors
  - Make active-mode requirements more stringent
  - Broaden scope to include digital photo frames and professional signage

Ongoing Developments with CE Products

- Televisions
  - Specification now covers active and low-power modes
  - Emerging network issues (e.g., TV with IP port)
  - Work toward harmonization with monitor spec
- Set-top boxes
  - Annual energy allowances for all major STB categories
  - Requires minimum purchase percentage by service providers
  - Requires product labeling and education

Projected Data Center Electricity Use 2007 to 2011



Includes power conversion and cooling

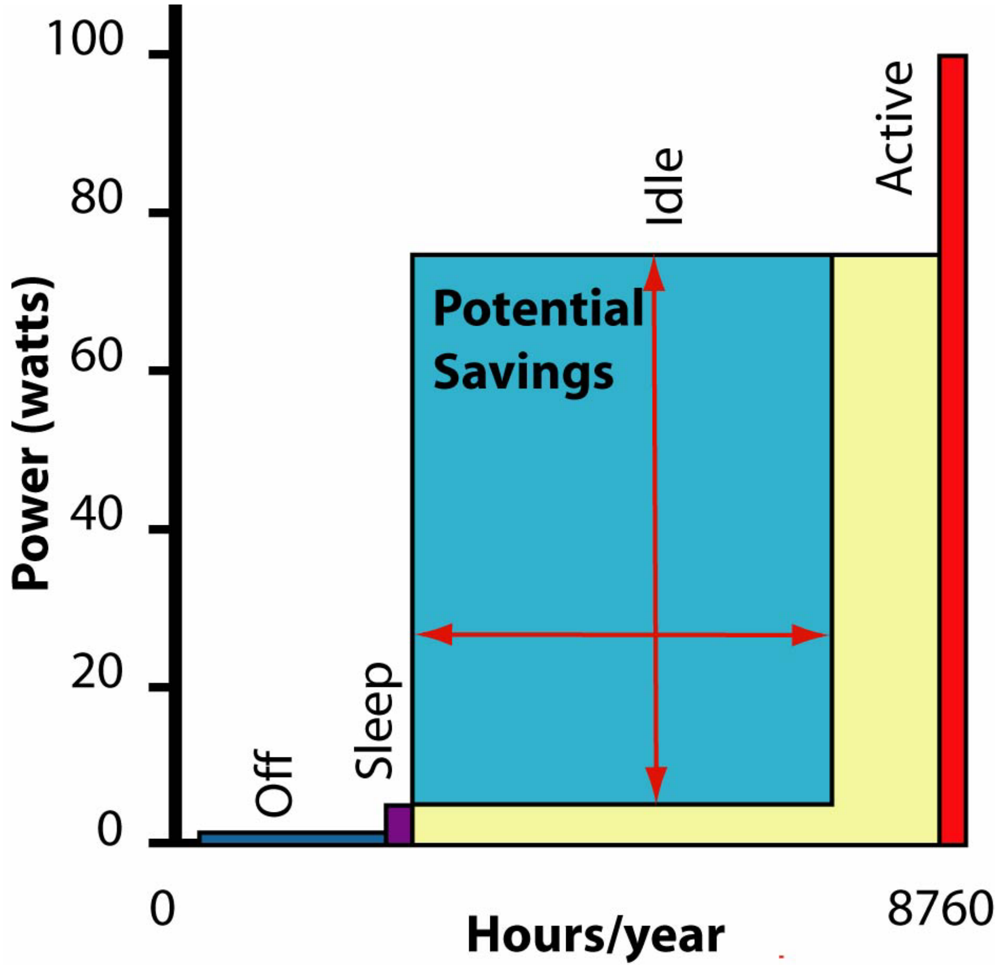
Source: EPA report to Congress, 2007

ENERGY STAR for Servers

- Current Tier 1 Considerations
  - Power supply efficiency and/or net power consumption
  - Standard reporting requirements (standardized data sheet)
  - Power and temperature network reporting requirements
  - Idle power – how prevalent in data center?
  - Power management and virtualization “hooks”
  - Effective December 2008
- Tier 2 Approach
  - Utilize industry developed energy performance benchmarks to derive requirements

Induced Energy Use in Networked Devices

Core Fact: Most PC energy use occurs when no one present



(Sorted by power level)

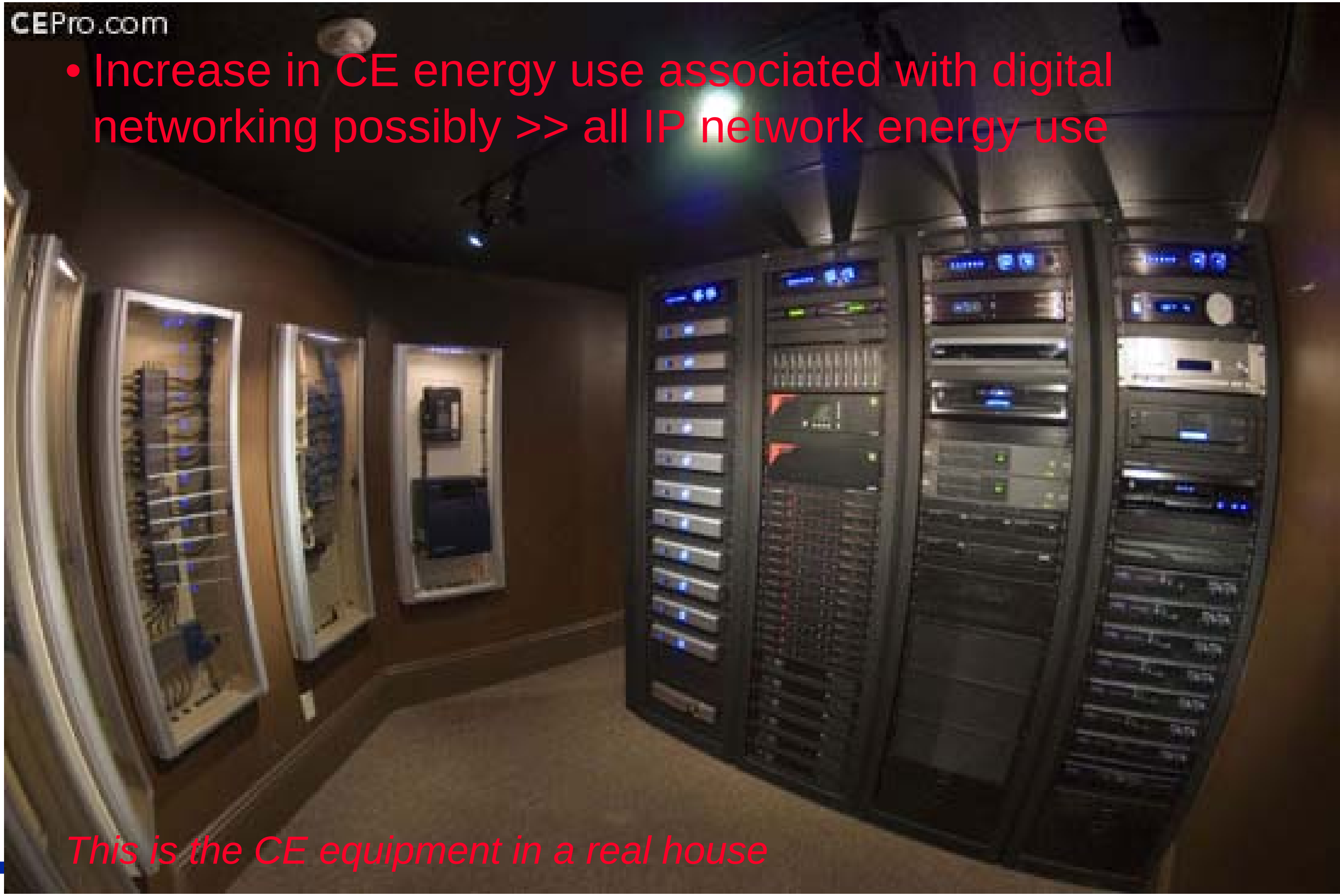
Most of time when idle, could be asleep

But networking often prevents sleep mode

PC savings potential is **most** of current consumption

Similar patterns apply to set-top boxes,
for TVs, printer, …

The Other Networks:
Consumer Electronics

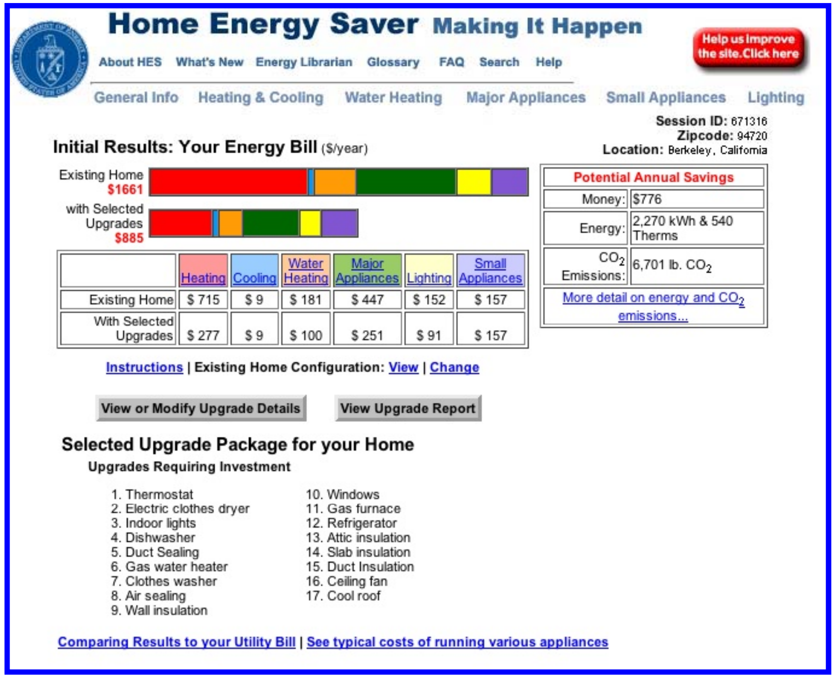


- Increase in CE energy use associated with digital networking possibly >> all IP network energy use

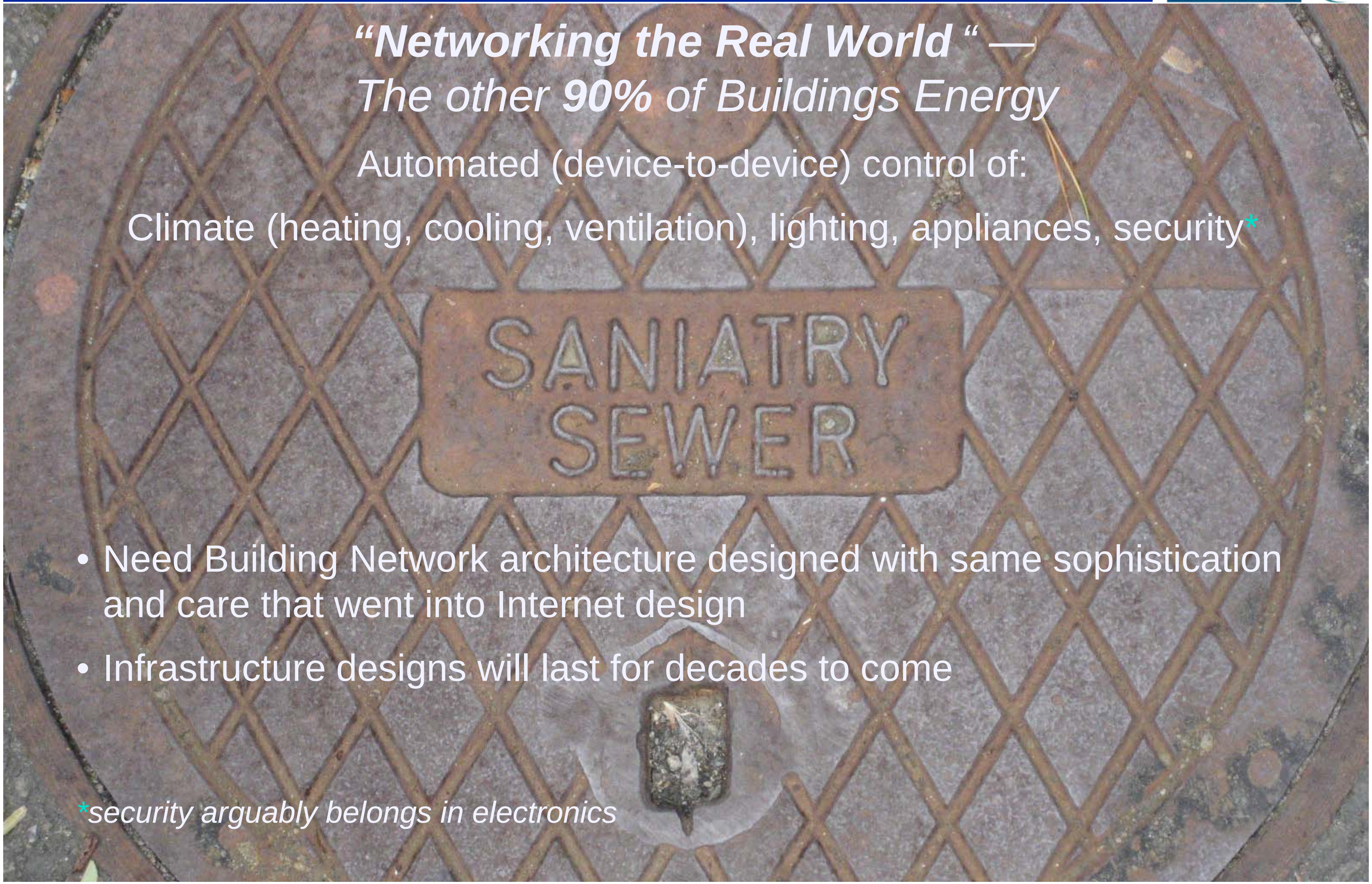
This is the CE equipment in a real house

Electronics/ICT Influence Energy-related Decisions

- "Human-mediated" design, purchase, and control decisions
- Building design tools (e.g., simulation models
- Energy analysis web tools (benchmarking, home retrofit analysis - hes.lbl.gov)
- Energy use feedback



The Other Networks:
Digital Networks for Building Control



***"Networking the Real World "* —**

*The other **90%** of Buildings Energy*

Automated (device-to-device) control of:

Climate (heating, cooling, ventilation), lighting, appliances, security*

- Need Building Network architecture designed with same sophistication and care that went into Internet design
- Infrastructure designs will last for decades to come

**security arguably belongs in electronics*

Examples of How NOT to do Building Networks

- IT (computer power management)
  - General network presence is lost when computer is asleep
  - Wake On LAN was implemented after the fact, and only works in some applications
  - Result: power management is disabled on most PCs
- CE (remote controls)
  - Remote control is main interface to CE devices
  - Concept of inter-device power control mostly does not exist
  - Result: devices left on when not in use

Future Scenarios of Building Networks

- Business as usual
  - Lack of interoperability
  - Lack of standardized user interfaces
  - Little coordination across domains
  - Increased energy use
- Design for energy efficiency
  - Networks use open international standards
  - Controls coordinated across domains (e.g., climate control and lighting)
  - Building controls are highly dynamic, to optimize service delivered and minimize energy

Building Networks Design Needs

- Need much work on network architecture issues for buildings
- Proposed 4-layer model for building control networks (apologies to OSI)

User Interface ***<= One Standard***

Diverse Standards => Applications

Concepts* ***<= One Standard***

Diverse Standards => Transport

Network, Data Link, Physical

- Policy and authority among multiple entities in buildings also key
- Global standards and diversity both essential for networks to be effective and usable

**Concepts may not be a true layer*

A Building Networks Agenda

- For ICT to do for buildings what the Internet and web did for information sharing, we need:
  - Global interoperability
  - Well-conceived network architecture (requires specialists in network architectures, not just energy, building, or climate specialists)
  - Institutions to develop and maintain the required standards

(more details: eetd.lbl.gov/EA/nordman/bldgsasnetworks.html)

Conclusions

- Electronics are important driver of building energy use, both *Directly* and *Indirectly*
- ENERGY STAR continuously evolving to better address direct energy use of electronics
- Networks are key driver of indirect energy use:
  - Induced energy use when low power modes not used
  - ICT an increasing tool for revealing savings opportunities in building design and use
  - Building Networks: large potential increases or decreases in building energy use due to networks (but no assurance that networking will improve energy efficiency)

Conclusions, con't.

- Success with building networks requires universal interoperability through a high-level policy commitment to global network architecture, protocols, and UI standards
- International harmonization is key to energy efficiency in electronics and network standards
- Magnitude of climate challenge driving policy-makers to look for all CO_2 reductions
  - McKinsey study: electronics lowest-cost mitigation option
  - Despite enabling savings elsewhere in economy, can't ignore electronics energy use

Thank You

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Estimated Life-Cycle GHG Emissions of California's Installed Base of PCs, 2005

Life-Cycle Phase	GHG Emissions (10^6 Mg CO_2e)		Total
	Inside CA	Outside CA	
Production	0.2	3.2	3.4
Use	1.9		1.9
End of Life	-0.01	-0.13	-0.14
Total	2.1	3.1	5.2

- **Total is equivalent to the annual GHG emissions of 1.16 million automobiles (4,500 kg CO_2e per car per year) or 1.3% of California's net GHG emissions in 2004**

Source: Derived from (1) Masanet, E., L. Price, S. de la Rue du Can, R. Brown, and E. Worrell (2005). *Optimization of Product Life Cycles to Reduce Greenhouse Gas Emissions in California*. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-110; and (2) Masanet, E., and A. Horvath (2006). *An Analysis of Measures for Reducing the Life-Cycle Energy Use and Greenhouse Gas Emissions of California's Personal Computers*. University of California Energy Institute Technical Report, Berkeley, California.

PC Life-Cycle GHG Emission Reduction Potential

Analysis of Select Policy Measures, 2005

Life-Cycle Phase	Measure*	Approximate Incremental Life-Cycle GHG Emission Reduction (%)**
Production	Improve manufacturing energy efficiency	6%
	Reduce PFC emissions from semiconductor manufacture	3%
Use	100% power management	8%
	Purchase ENERGY STAR v3.0 compliant PCs	1%
	Turn PC off during periods of non-use	2%
End of Life	Upgrade to extend PC life by 50%	7%
	Maximize recycling of PC control units	1%
Total		28%

* Measures are applied in a cascading fashion

** % reduction with respect to 2005 California PC life-cycle GHG emissions of 5.9×10^6 Mg CO_2e

Source: Derived from (1) Masanet, E., L. Price, S. de la Rue du Can, R. Brown, and E. Worrell (2005). *Optimization of Product Life Cycles to Reduce Greenhouse Gas Emissions in California*. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-110; and (2) Masanet, E., and A. Horvath (2006). *An Analysis of Measures for Reducing the Life-Cycle Energy Use and Greenhouse Gas Emissions of California's Personal Computers*. University of California Energy Institute Technical Report, Berkeley, California.

Points of view

Design vs. Energy

Issue \ Perspective	Product Design	Energy Efficiency
Throughput	Maximum	Typical
Power Consumption	Maximum (TDP)	Average
Usage cases / contexts	All	Most
Who	Manufacturers, Standards orgs.	Users (data centers, businesses, consumers), energy / env. orgs.

New role for industry & standards orgs?