The Case "Against" the Smart Grid

Bruce Nordman
Lawrence Berkeley National Laboratory
October 2, 2009

BNordman@LBL.gov — eetd.LBL.gov/EA/Nordman

C1TR1S I4E Seminar – Fall 2009

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Approach

- Depict situation slightly more extreme than actual
- Use this to clarify conclusions and what is missing

This a work in progress —
Your help needed

What I hope you leave with

Conclusions for future

- Problems with current discourse around "Smart Grid"
- Proposed architecture and design approach for "Building Networks"
- Research and policy needs

But first, lessons from past

- Past experience with IT and energy
- Lessons from Internet development

In Scope

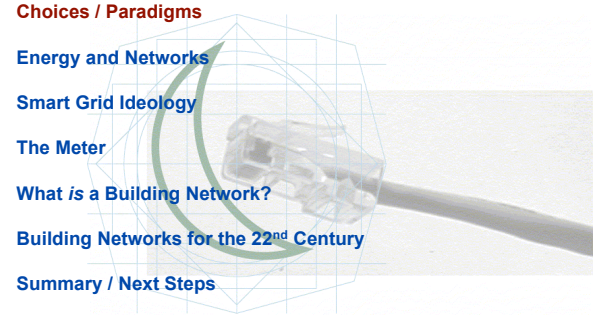
- Residential buildings
- Commercial buildings
- People
- The meter

Not in Scope

- Industrial energy use
- Sensor networks
- The meter
- **Anything** on the grid side of the meter

Agenda

Agenda



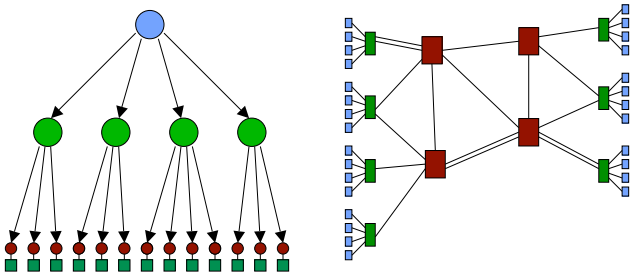
- Choices / Paradigms
- Energy and Networks
- Smart Grid Ideology
- The Meter
- What *is* a Building Network?
- Building Networks for the 22nd Century
- Summary / Next Steps

Choices for our future — Ranges of design options

Centralized ⟷ Distributed

- Many decisions are between opposites
- Choice need not be at either extreme
  - –But location matters
  - –Consequences can last for years or decades

Controls vs. Networks



- Locus of authority
- Integration of controls
- Fragility vs. robustness
- Ease of implementation

Key challenges for our path forward

Controls ⟷ Networks

Central ⟷ Distributed

Devices/Energy ⟷ People

Non-Interoperable ⟷ Interoperable

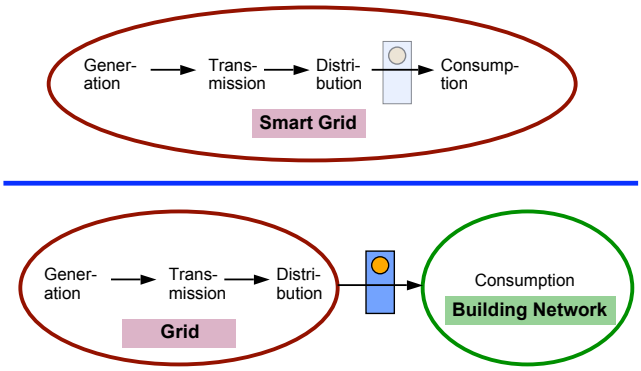
Local ⟷ Universal

Utility controlled ⟷ User controlled

Production ⟷ Consumption

Near Term ⟷ Long Term

Two Electricity Paradigms



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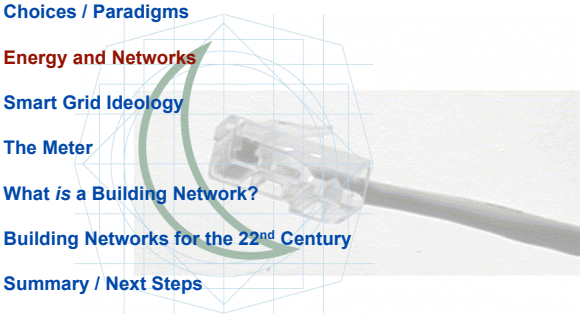

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Past Experience with Networks & Energy

- **IT Networks**
  - Not designed with energy in mind
  - "Tacking on" energy features not successful
  - Path forward clear
  - Industry not opposed to working with energy people
- **CE Networks**
  - Not designed with energy in mind
  - A mess at all layers
  - Energy/efficiency not a priority for industry
  - Path forward murky
  - Progress possible if energy community leads

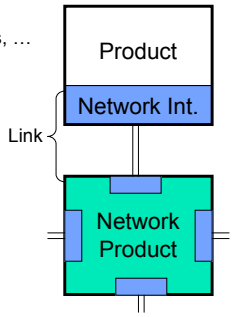
Complexity

While some integrators are skeptical about the prewired, preprogrammed NHS rack from Sony, others embrace the solution for its simplicity.

- Complexity is easy
  - Ordinary outcome
- Simplicity is hard
  - Doable
  - Well worth effort

Networks and Energy

Network equipment ….
Routers, switches, modems, wireless APs, …
… vs **networked** equipment
PCs, printers, set-top boxes, …

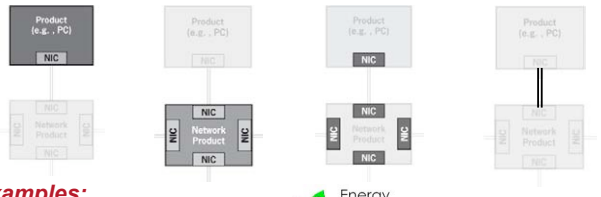


How networks drive energy use

- **Direct**
  - Network interfaces (NICs)
  - Network products
- **Induced in Networked products**
  - Increased power levels
  - Increased time in higher power modes (to maintain network presence)

Efficiency Approaches

Product Focus	Network Product Focus	Interface Focus	Protocol / Application Focus



Examples:

Proxying

Energy Efficient Ethernet

CE

Efficiency Approaches

Product Focus	Network Product Focus	Interface Focus	Protocol / Application Focus

Key Lessons
- Comprehensive
- Holistic

Examples:

Proxying

Energy Efficient Ethernet

CE

Interdependence in Networks

- The behavior on the network of one device can change the energy use of devices it is connected to

Electronics as an End Use

- Electronics are an end use of electricity

  "Devices whose primary function is Information (obtain, store, manage, communicate, present)"

  – Includes both Information Technology (IT) and Consumer Electronics (CE)

- Conventional end uses all based in **physics**
  - (heating/cooling, lighting, appliances, hot water, …)
- Electronics based in **information**
- About 10% of buildings electricity*
- < 1/5 of Electronics energy use is in data centers
- Digital connectivity substantial and increasing

Network standards are like laws of physics — Can mandate or prohibit energy-saving features

Lessons from Internet development

- Make quantum leaps in system architecture
  - –Don't just slowly evolve
  - –Design for functionality / applications not yet imagined
- Be prepared to jettison any/all existing technology
  - –Including short-term developments
- Embrace "Universal Interoperability"
- Use experimental times wisely
- Use distributed architecture
  - –smart hosts; dumb network

Don't aim to build a better phone system

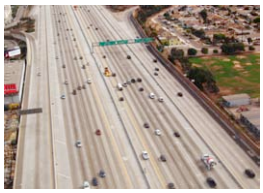
Networks

- **Internet** enabled networking of our information world
- **Building networks** a key to networking the physical world

- Building networks ultimately a subset of, not distinct from, general network

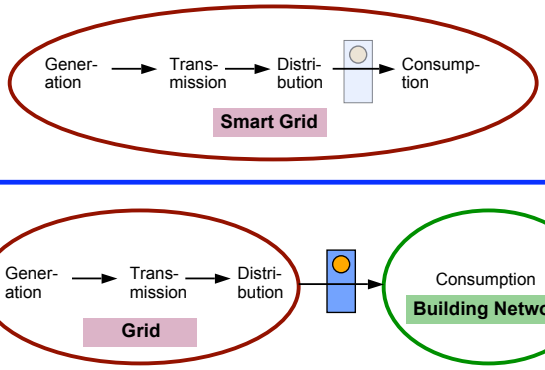
Agenda

Vehicle Transport - a domain example

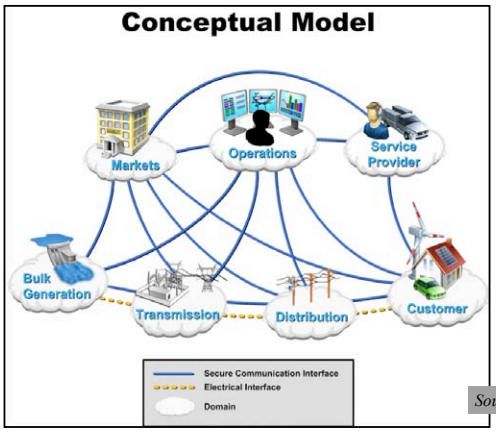


Transport Domains - well-defined interface

Two Electricity Paradigms

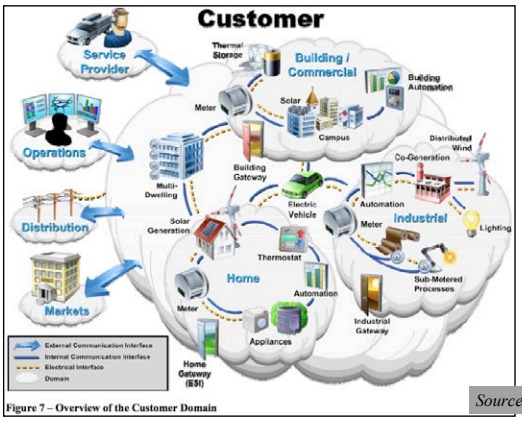


What IS the Smart Grid?



Source: NIST

What IS the Smart Grid?



Source: NIST

The "Smart Grid" by law — "EISA"

IN THE SENATE OF THE UNITED STATES—110th Cong., 1st Sess.

H. R. 6

.....

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Energy Independence and Security Act of 2007".

EISA on Smart Grid

SEC. 1301. STATEMENT OF POLICY ON MODERNIZATION OF ELECTRICITY GRID.

It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a **Smart Grid**:

(1) Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.

(2) Dynamic optimization of grid operations and resources, with full cyber-security.

(3) Deployment and integration of distributed resources and generation, including renewable resources.

(4) Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.

(5) Deployment of `smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.

(6) Integration of `smart' appliances and consumer devices.

(7) Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.

(8) Provision to consumers of timely information and control options.

(9) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.

(10) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.

EISA on Smart Grid (abbreviated)

SEC. 1301. STATEMENT OF POLICY ON MODERNIZATION OF ELECTRICITY GRID. … **Smart Grid**:

(1) … digital information and controls technology to improve reliability, security, and efficiency of the … grid.

(2) Dynamic optimization of grid operations and resources ….

(3) … integration of distributed resources and generation, including renewable ...

(4) … **demand response, demand-side resources, and energy-efficiency resources.**

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(8) Provision to consumers of timely information and control options.

(9) … standards for communication and interoperability of appliances and equipment connected to the electric grid …

(10) … lowering of .. barriers to adoption of smart grid …

Most topics are about **building efficiency** or take place in buildings.

What is wrong with "Smart Grid"?

- Presented as ***the way*** we will apply information technology and communication to improving our electricity system
- Presented as spanning from power plants through to end use devices
- "Smart" name
- "Grid" presented as best overall metaphor

Consequences of "Smart Grid" Thinking

- For Grid
  - –Buildings topics distract from work on real grid
- For Building Networks
  - –No broad understanding of potential
  - –Assign building network savings to Smart Grid
  - –Impedes research into building networks
  - –Enables controls paradigm to flourish longer
  - –Have wrong institutions & people involved

How did this happen?

- Need for dynamic prices, hence time-of-use meters
  - –Opposition to spending money on and/or using these
- Need for better ability to integrate distributed and dynamic renewables
- Obvious benefits of using modern communications technology
- Convenient, and logical, to package all together

voila' — le Smart Grid

How did buildings angle get added?

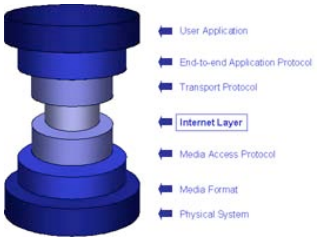
Speculation Alert

- No confidence that people will actually respond to dynamic prices
- Real need to ensure availability of prices to devices in buildings
- Grid is boring (relatively)
- Utilities have real needs/desires to reach into buildings
  - –Retail "electrons" a declining business due to self-generation and efficiency
  - –Need to identify new sources of revenue
  - –Need to justify Smart Grid costs on savings within buildings

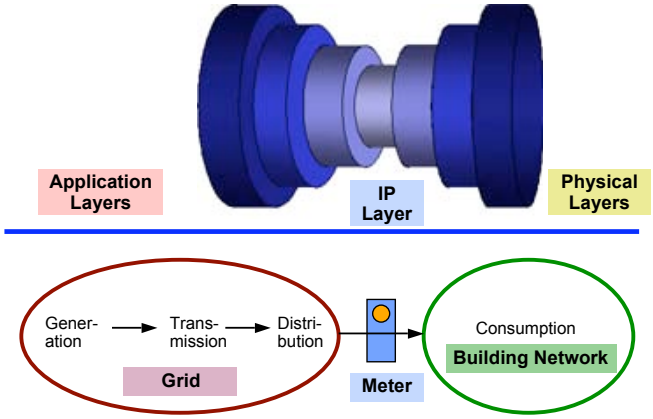
Agenda

Proper Role of Meter in "Future Grid"

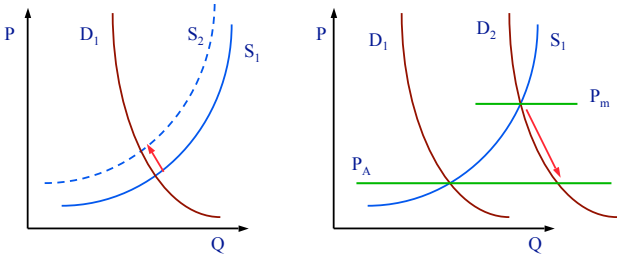
- Meter is a "Narrow waist"
  - Like Internet Protocol (IP) for Internet
- Meter based on one-way communication
  - Current price, price forecast, emergency
- Possible exceptions
  - Local generation
  - Local storage
  - Vehicle charging



Two Narrow Waists



What about prices?

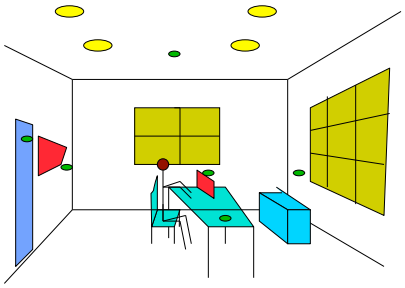


Not charging real marginal prices leads to using too much electricity and paying too little

Agenda

What is a building network?

- People
- Light Sources
- Light modifiers
- Thermal sources, ventilation
- Displays
- Sensors
- Appliances



Building Network Principles

- Any device in a room [building] can talk to any other
- People are nodes on the network
- Devices seek to optimize functionality as best they can
- Then they seek to be energy efficient

Building Network Layers

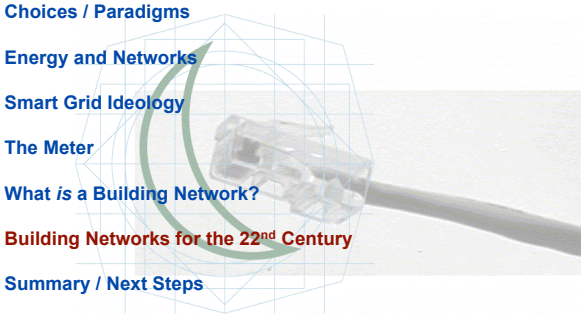
- User Interface
- Protocols
- Common Data Model
- Standard network layers 1-4

Building networks today

- At an early stage of development
- Not inevitable that building networks will save energy
- Most activity in building networks is driven by short-term business interests, not saving energy
- "Home Automation" to date rarely informed by energy

- Building networks best understood as a means to provide **functionality**, NOT as a means to save **energy**

Agenda



Choices / Paradigms

Energy and Networks

Smart Grid Ideology

The Meter

What *is* a Building Network?

Building Networks for the 22nd Century

Summary / Next Steps

Key challenges for our path forward

Controls	⟷	Networks
Central	⟷	Distributed
Devices/Energy	⟷	People
Non-Interoperable	⟷	Interoperable
Local	⟷	Universal
Utility controlled	⟷	User controlled
Production	⟷	Consumption
Near Term	⟷	Long Term

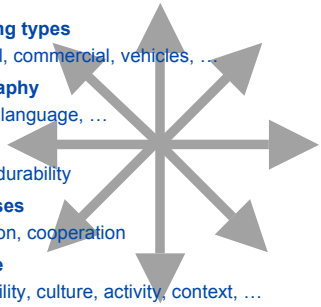
Building Network Principles

- Use network netaphor, not controls
- Use distributed control, not central
- Design for people's needs, not device's
- Design for functionality first, not energy
- Adopt Universal Interoperability
- Bring utilities past meter only when truly needed

Universal Interoperability

Any device should work with all other objects in any space

- Across **building types**
  - Residential, commercial, vehicles, …
- Across **geography**
  - Countries, language, …
- Across **time**
  - Worthy of durability
- Across **end uses**
  - Coordination, cooperation
- Across **people**
  - Age, disability, culture, activity, context, …



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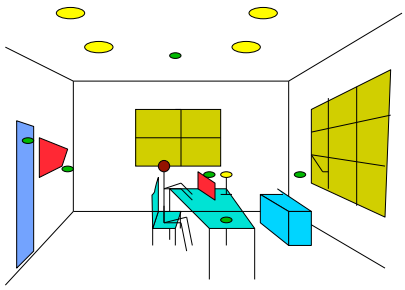

really good
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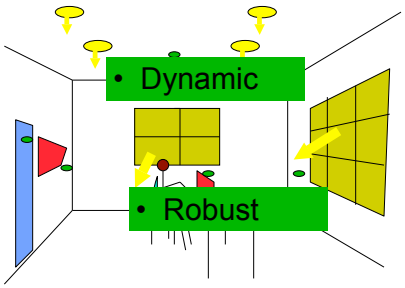


• Efficient

Represent the *physical* world in the *information* world

- Need a standard "dictionary": things, ideas, principles, actions, etc.
  - Standard "names" for common elements
    - Standard translations for all languages
  - Embody these in protocols, data dictionaries
  - Embody in user interfaces
  - Identify the meaning (semantics) of the information
    - not how it is encoded or represented …
    - … except as corresponds to the user interface

build·ing [bil-ding] net·work [nĕt'wûrk']

Physical World Concepts

- Building elements (energy using or not)
  - Lights, climate control devices, windows, displays, rooms, sensors, appliances, people, …
- Ideas
  - Presence, schedules, prices, events, preferences, …
- Characteristics
  - Physical location, power levels, light levels, …
- Actions
  - Dim, open, go to sleep, …
  - Announcing and requesting

"Affordances"; metaphors

Standard Concepts

- User Interfaces
  - Automobiles: controls, roads, …
  - Tape transport: Play, pause, stop, fast-forward, eject, …
- Document conventions
  - Fonts, margins, headings, columns, …
  - Web page conventions: forward, back, navigation, links, …
- Data and File formats
  - ASCII, PDF, HTML, …
- Email conventions
  - Structure, addressing, …

All present in device ⇔ device and device ⇔ person communication

Protocols

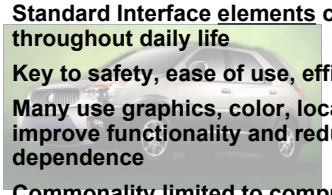
- ???

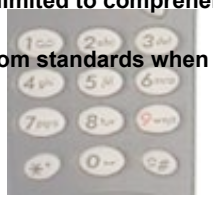
People

- … are often absent from design, presentation
- … best understood as nodes on the building network
  - Even more than portable electronics, they move
- … need standard interfaces, just like devices do
  - Nature of interface different, but principle same
- User interface design should be a starting point
  - to help create dictionary
  - before we design protocols
- Ensure that devices are adaptable to different people
  - Needs, desires, capabilities

User Interfaces

- **Standard Interface elements common throughout daily life**
- **Key to safety, ease of use, efficiency**
- **Many use graphics, color, location, etc. to improve functionality and reduce language-dependence**
- **Commonality limited to comprehension needs**
- **Can deviate from standards when there is a good reason**



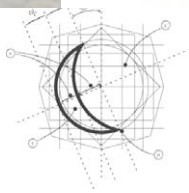




User Interfaces

- Consistent across:
  - Manufacturers
  - Products
  - Countries
- Simple
- Accessible
- Portable

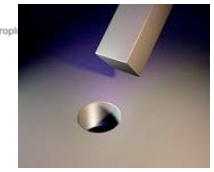
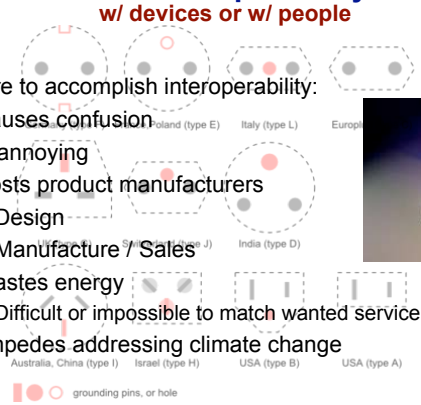
Key Elements
- *Terms*
- *Symbols*
- *Colors*
- *Metaphors*
- *…*



Non-Interoperability
w/ devices or w/ people

- Failure to accomplish interoperability:
  - Causes confusion
  - Is annoying
  - Costs product manufacturers
    - Design
    - Manufacture / Sales
  - Wastes energy
    - Difficult or impossible to match wanted service to delivered
  - Impedes addressing climate change

(lack of) Interoperability Examples

- **Why so many connectors?**

- **Why so many remotes?**

Source:http://www.useit.com/alertbox/20040607.html

Agenda

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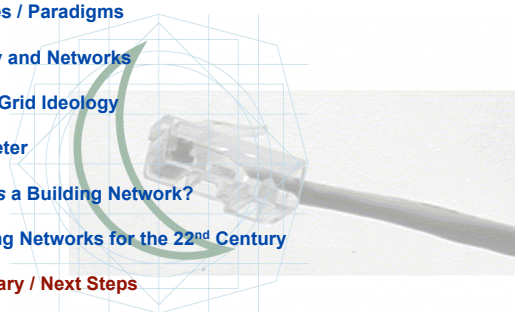
What *is* a Building Network?

Building Networks for the 22nd Century

Summary / Next Steps



Building Networks for 22nd Century — Key Principles

- Learn from Internet
- Adopt standard network technology through layer 4
- Be prepared to jettison any/all existing technology
  - –Including short-term developments
- Embrace “Universal interoperability”
- Begin designs with users, user interface
- Use distributed architecture
- Design around functionality, not energy
- Use price as way to change demand

Building Networks are a new way to save energy
—large amounts; inexpensively

Building Networks and the "Smart Grid"

- If the "Smart Grid" extends through the meter:
  - (I assume real-time pricing; don't care how transmitted)
  - Suggests one architecture that extends from power plant to each end-use device
  - Will impede improvements in grid
  - Will impede improvements in buildings
  - No barrier to occasional "opt-in" agreements / exchanges between devices and outside entities
    - Demand response, local generation and storage, ..
  - The meter is our friend

Next Steps

- Adopt Building Network design as a key efficiency priority
- Fund academic research on key topics
  - Presence, authority, security, user interfaces, network architecture, failure modes, emergencies, protocol design, …
- Don't worry about physical layers
- Create Building Network Task Force (BNTF) as sibling to Internet Engineering Task Force (IETF)
  - --IETF is part of Internet Society (isoc.org)
- Revisit related topics in light of this
  - Real-time pricing, demand response, "smart grids", …
- Get started ASAP

Thank You

eetd.lbl.gov/ea/nordman

Bruce Nordman
Lawrence Berkeley National Laboratory
BNordman@LBL.gov
510-486-7089
(or just google me)

ENERGY EFFICIENT DIGITAL NETWORKS