Smart Grid Day at MWDRI

MADRI Working Group

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Get Beyond Hype

- Regulators get lots of fragmented messages about smart grid
- Yet they have little opportunity to get perspective on its implications, especially outside a contested case in their states
  - What does it do now for average people and average businesses?
  - How might smart grid change and integrate into people's lives in the next years?

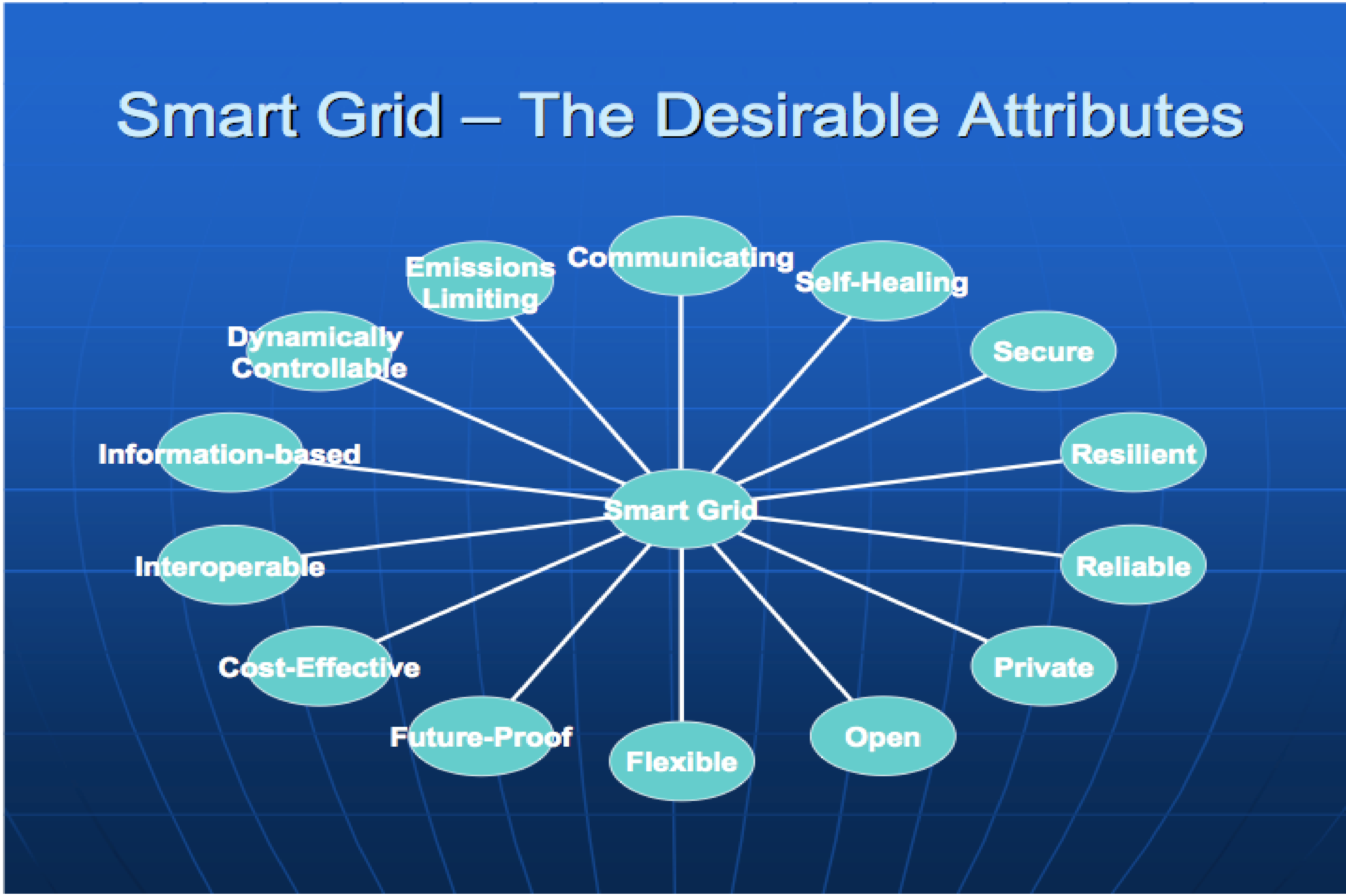
How to do it

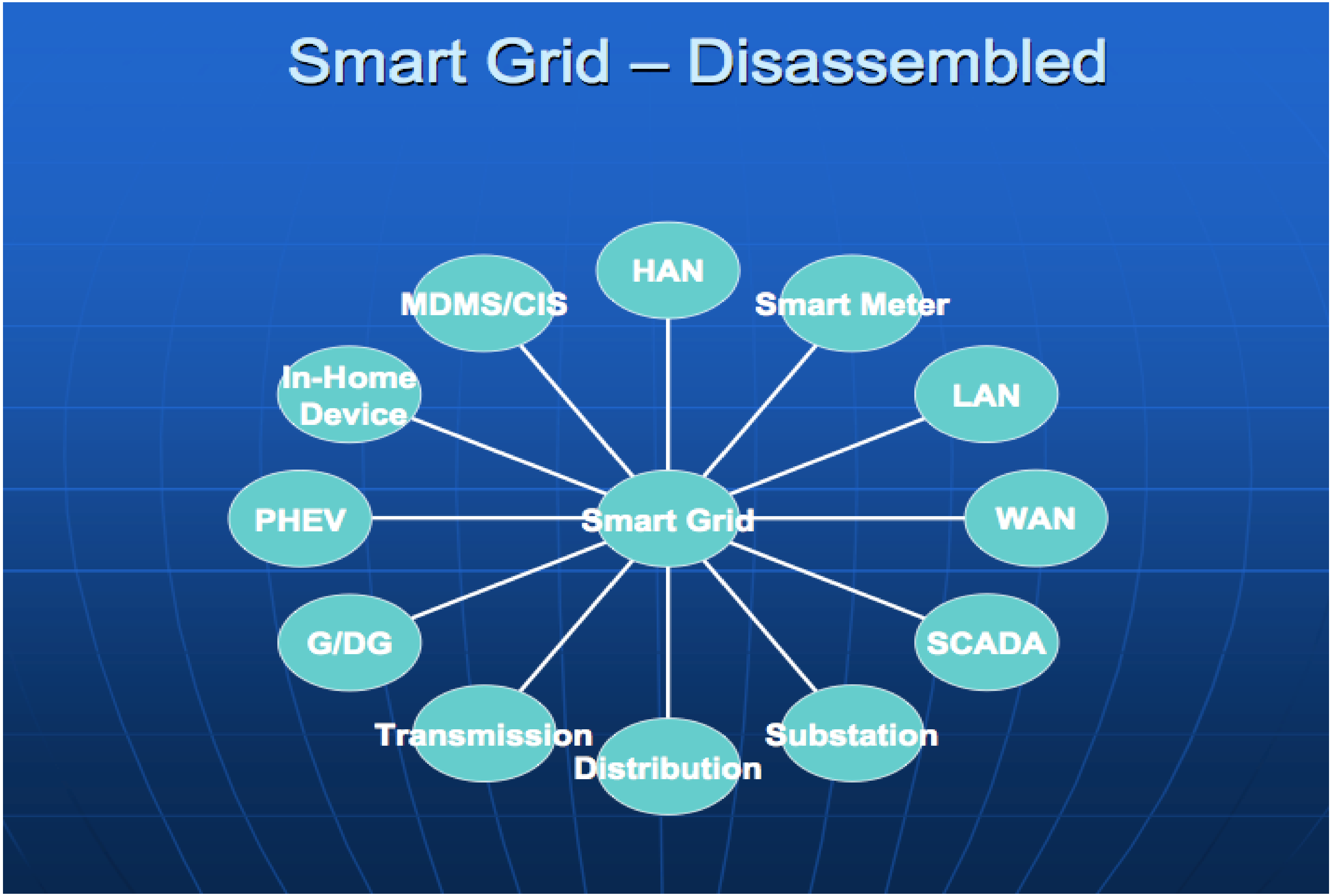
- Get leaders who know what they are talking about
- Those that sell stuff, ask them to tone down the commercial and get to the essence
  - Not a trade show
  - Demonstrations part of the program
- MWDRI: Midwest Distributed Resources Initiative, an activity of the Organization of MISO States

MWDRI Smart Grid Day Agenda: Customer-side

- Smart Grid Overview: *Alison Silverstein*
- Home Area Networks and Communications: *Paul Nagel*, *Control 4*
- Smart Appliances: *Gale Horst*, *Whirlpool*
- Automated Commercial Buildings: *Chris Tomasini*, *Site Controls*
- Demo of Lighting Reduction: *Chris Hickman*, *Site Controls*
- Interoperability: *Erich Gunther*, *Enernex*

Overview


Smart Grid – The Desirable Attributes
Communicating
Emissions Limiting
Self-Healing
Dynamically Controllable
Secure
Information-based
Resilient
Smart Grid
Interoperable
Reliable
Cost-Effective
Private
Future-Proof
Flexible
Open


Smart Grid – Disassembled
HAN
MDMS/CIS
Smart Meter
In-Home Device
LAN
PHEV
Smart Grid
WAN
G/DG
SCADA
Transmission
Distribution
Substation

Electric Grid about More than Electricity

Three flows across integrated networks:

- Electricity
- Information
- Money

The smart grid is a way to better facilitate and manage all those flows and transactions into a cooperative, collaborative, transactive, reliable system

Smart Grid: technology and physical assets

- Advanced hardware (power electronics, more efficient generation, meters, appliances and end-use devices, communications networks)
- Advanced software (better modeling and data analysis, linkage between applications, communications)
- Advanced materials (cables, silicon, superconductors, semiconductors)

To produce better grid efficiency and reliability using interoperability and distributed, interactive intelligence embedded across the network and its actors.

Smart grid supports efficiency, demand response, renewables, distributed generation, PHEVs…

And…

- Information
  - The value of electricity across time and place
  - The condition of the grid
  - The condition of the various elements of the grid
  - Presented to entities (people, institutions, devices) that can use it, in ways that they can understand and act on
- Customers
  - They consume, consider, respond, interact
  - They respond for reasons that may have nothing to do with what utilities or regulators value

Help the Utility

There are a number of key areas that can yield synergies between existing initiatives and smart grid efforts

Common Areas of Opportunity

Distribution
- Planning
- Capacitor Control
- Pole Top Automation

Substation
- Micro Processing Relaying
- Equipment Diagnostics
- Security

Network
- Control
- Monitoring
- Communication Channels

Transmission
- Line Temperature Monitoring
- Security
- Smart Substation

AMI
- Pilot Programs
- Data Warehousing Review
- Open Architecture

Communications
- Next Generation Network Plan
- Upgrading Core Systems
- Retail services

Make it easier for customers

- Customers respond
  - To what they understand (prices, times, interface)
  - If they care about what happens

Optimality is Elusive

- Most smart grid descriptions talk about optimizing stuff
  - Minimal cost
  - Optimized for this or that
  - But optimization can only happen in a command-and-control network
- But the essence of the smart grid is that multiple actors make independent decisions within a network of interrelated devices
  - Absent centralized analytics and command-and-control, we can't optimize, we can only make the various parts of the system work better internally, and then work well together
  - Lots of local optimization and cooperation will produce a very good outcome even if it's not "optimal"

Interoperability

The ability of two or more networks, systems, devices, applications or components to exchange information between them and to use the information so exchanged, in ways that don't inconvenience the user

- Interoperability requires interconnectivity and interaction agreement between hardware and software to enable effective communications, coordination and control.
- Interoperability is achieved when users' *expectations* to exchange and use information among various devices and software applications from multiple vendors or service providers are met or exceeded.

Home Area Networks

Home Area Networks: Distillation of Control 4 ppt

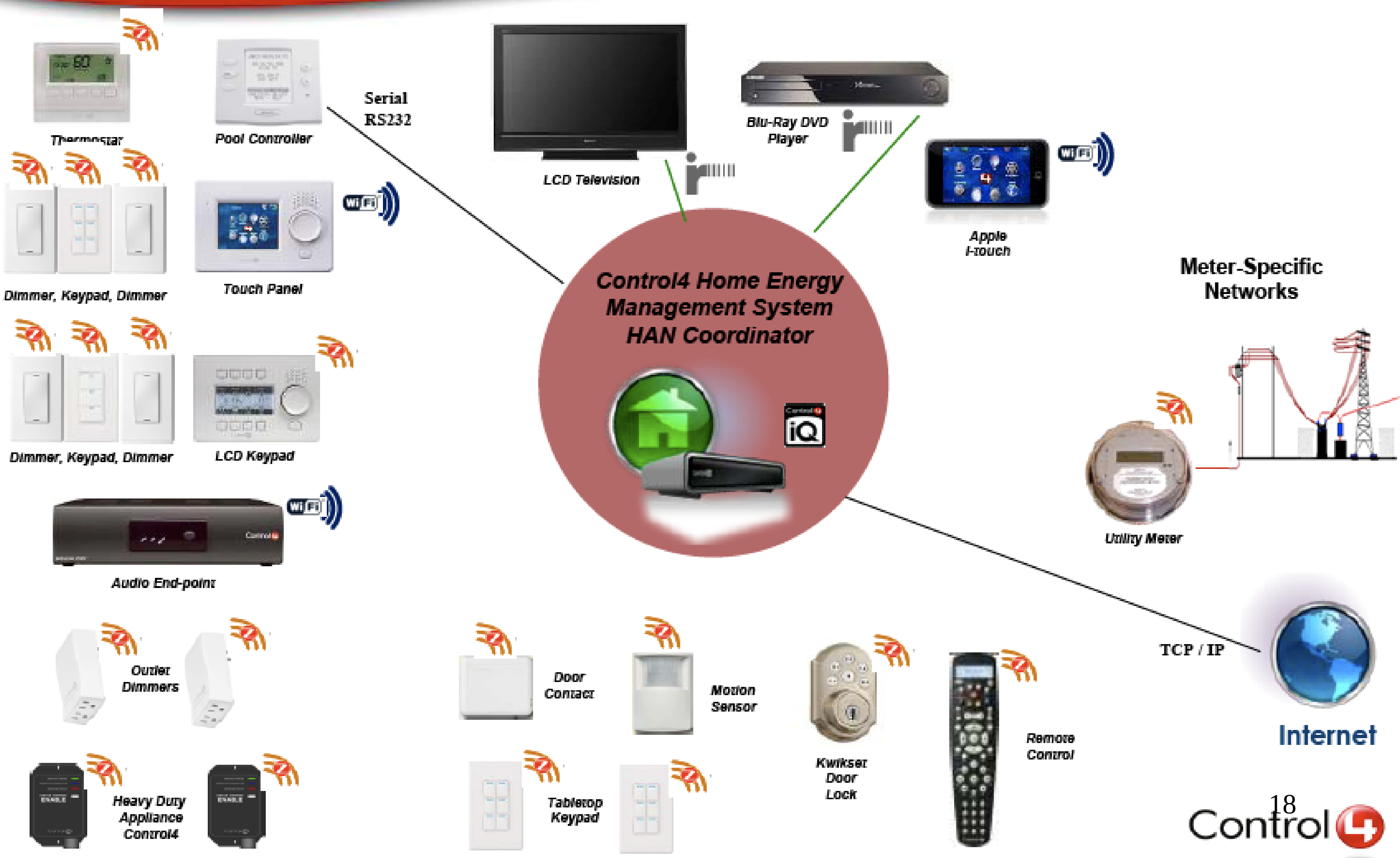
- There is no one in-home communication standard now
  - They use Ethernet, WiFi, Zigbee

- Homeowners want devices to work together
  - Easier in new and newer homes

Forecast Path of Progress

- 1. One entry point: programmable communicating thermostat
- 1. Another entry point: home entertainment
- 2. After first use, more choices and options are possible, including some that can be registered in a demand response program
- 3. Maturing and ubiquity

HAN Controller Provides Interoperability / Control Across Multiple Technologies



Home Energy Management

- Challenge of communicating to consumer:
  - Real time energy use and price
  - News utility grid events understandably
- Opportunity (*Control 4 approach*)
  - Use the television!
  - Be flexible about connectivity


Home Theater
Music
TV
Radio
Videos
Comfort
Info
Lights
House
Control4
Control4

Cited Benefits

- Advanced information
  - Energy use at any time, over time, by device category, and how to use the info
- Choice
  - Preset customer preferences, options for action
- Control
  - See the result of devices switching on/off, difference between efficiency and behavior, “away” setting

Customer Notification

VISUALLY:

- Through the homeowners existing television or another Control4 compatible touch screen, or PC web interface, event notifications can Pop-up (if configured to so).

AUDIBLE:

- The Control4 HEMS has the ability to play stored digital audio from connections in the back of the unit or via a remote end point using Ethernet or WIFI.
- The digital audio can be in any language or play multiple messages in multiple languages.

EMAIL ALERTS:

- If the homeowner has internet access, then the Control HEM can send email alerts to any number of devices or addresses.

PORTABLE DEVICES

- Remote control – Events can be sent to the Control4 remote control
- Cellular phone – if the homeowner has internet connection, then visual and audio messages can be sent to the cellular phone (if phone is capable)

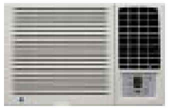
LIGHTING CONTROL DEVICE:

- If you have Control4 lighting in part or all of your home, then the tri-color LED's on the device can re-enforce the CPP or DR "color" mode on the LED's.
- When in this mode, the lighting MAXIMUM level can be adjusted.

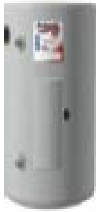
Control4

Heavy Duty Appliance Module

- Measures device:
  Voltage, Current, Frequency and power factor to 5% accuracy
- Zigbee enabled device
- Supports Manual over-ride allows the customer to over-ride the event.
- Utility Status:
  Normal, CPP or Emergency Event
- LED indication of Power Consumption
- Device Status:
  Indicates current condition the device.
  Normal, Disconnected, DR pending GO
- Supports DELAY and CYCLE modes








Control4

Utility Information Portal (that’s a Television)

- We watched a demo that showed
  - the various appliances controlled by messages coming from the utility
  - Information presented to the customer
- Preset responses by thermostat, lights, etc. that we could change

Home Owner – Utility Information Portal

Total Daily Energy Use and Current Energy Rate is displayed

Control4

Home Owner – Utility Information Portal

Home owner can see how much energy and the price they are paying throughout the day.

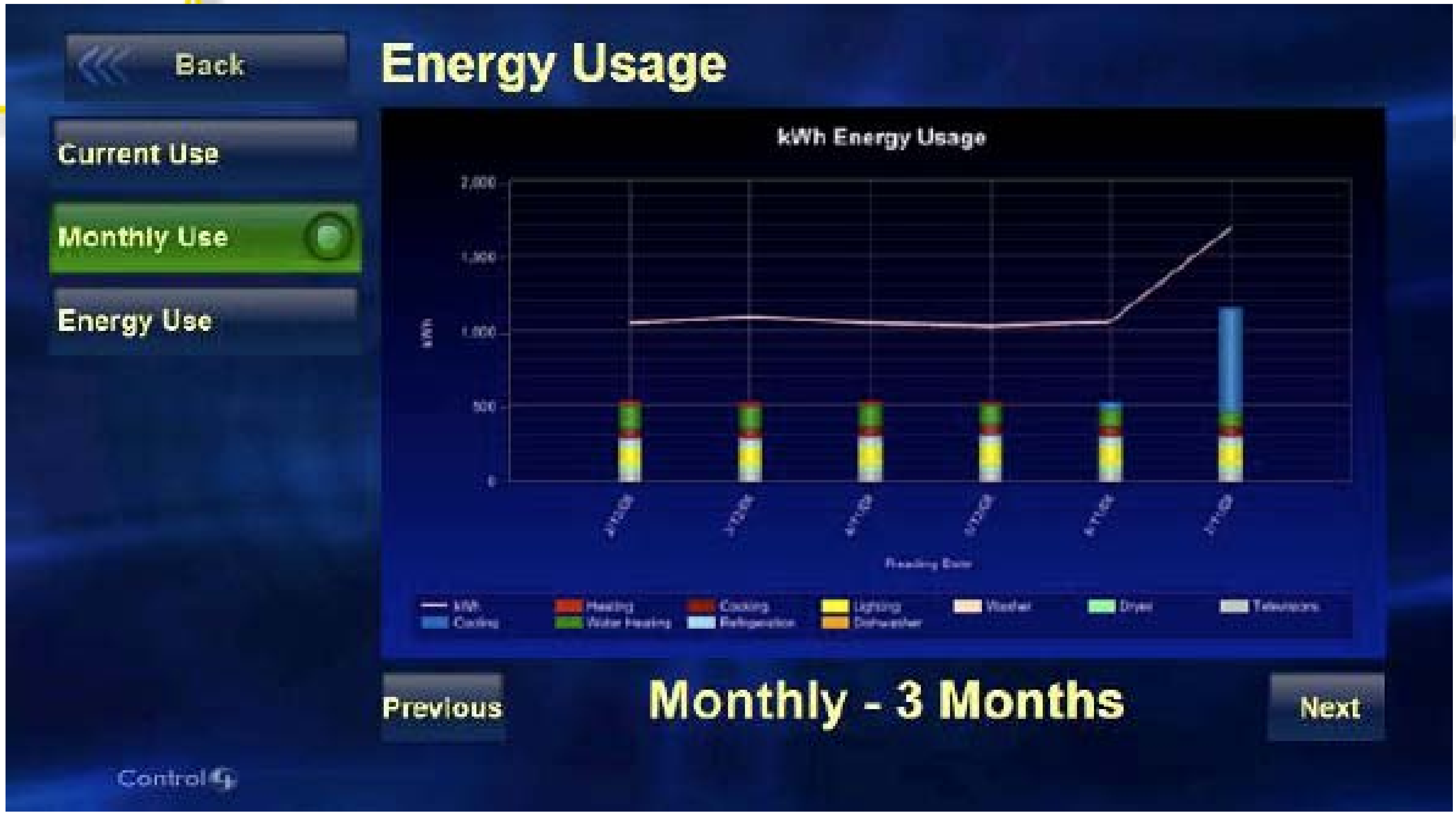
Home Owner – Utility Information Portal

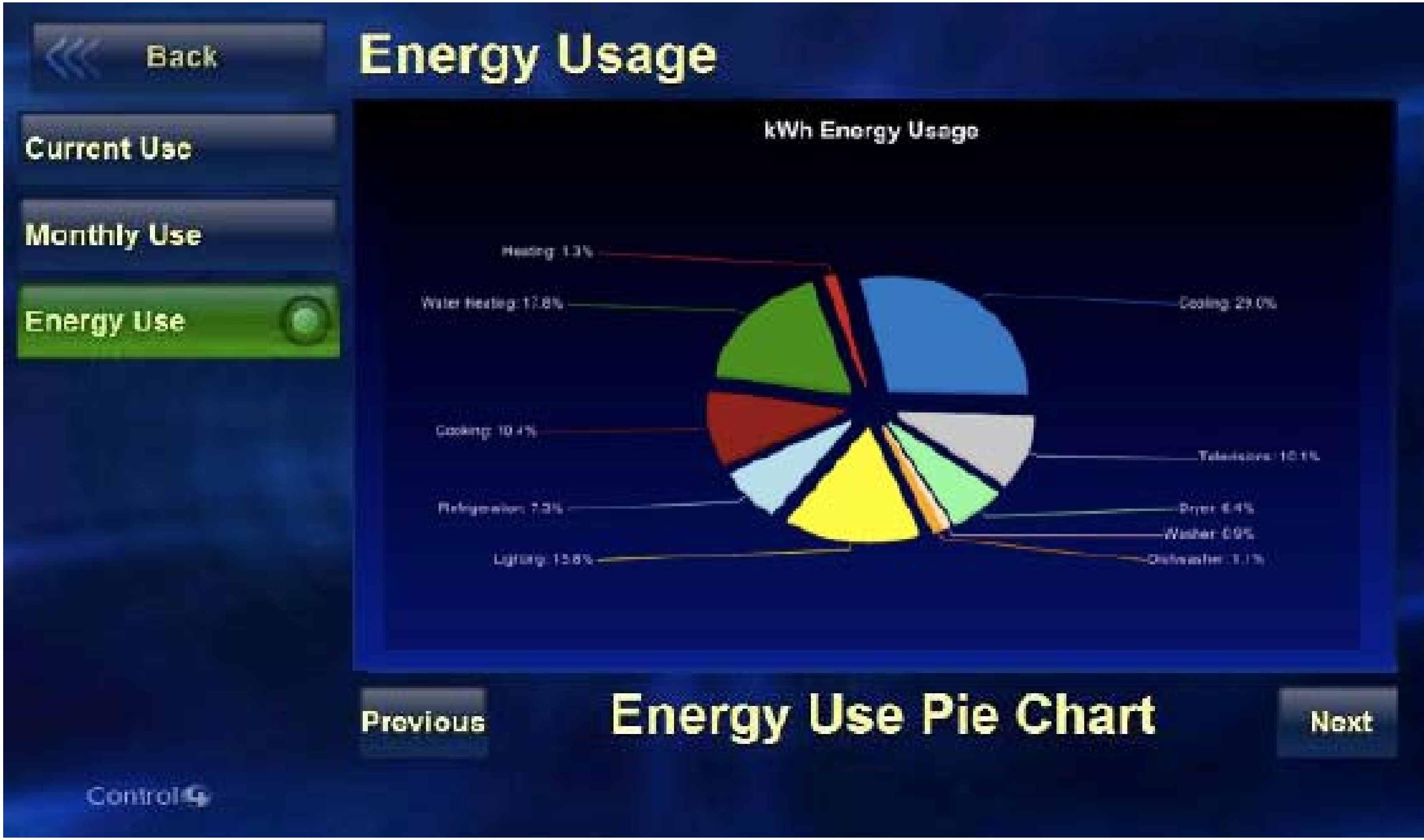
Home owner can see how much energy and the price they are paying throughout the day.

Home Owner – Utility Information Portal

Home owner sees historical energy use over prior months

Control4

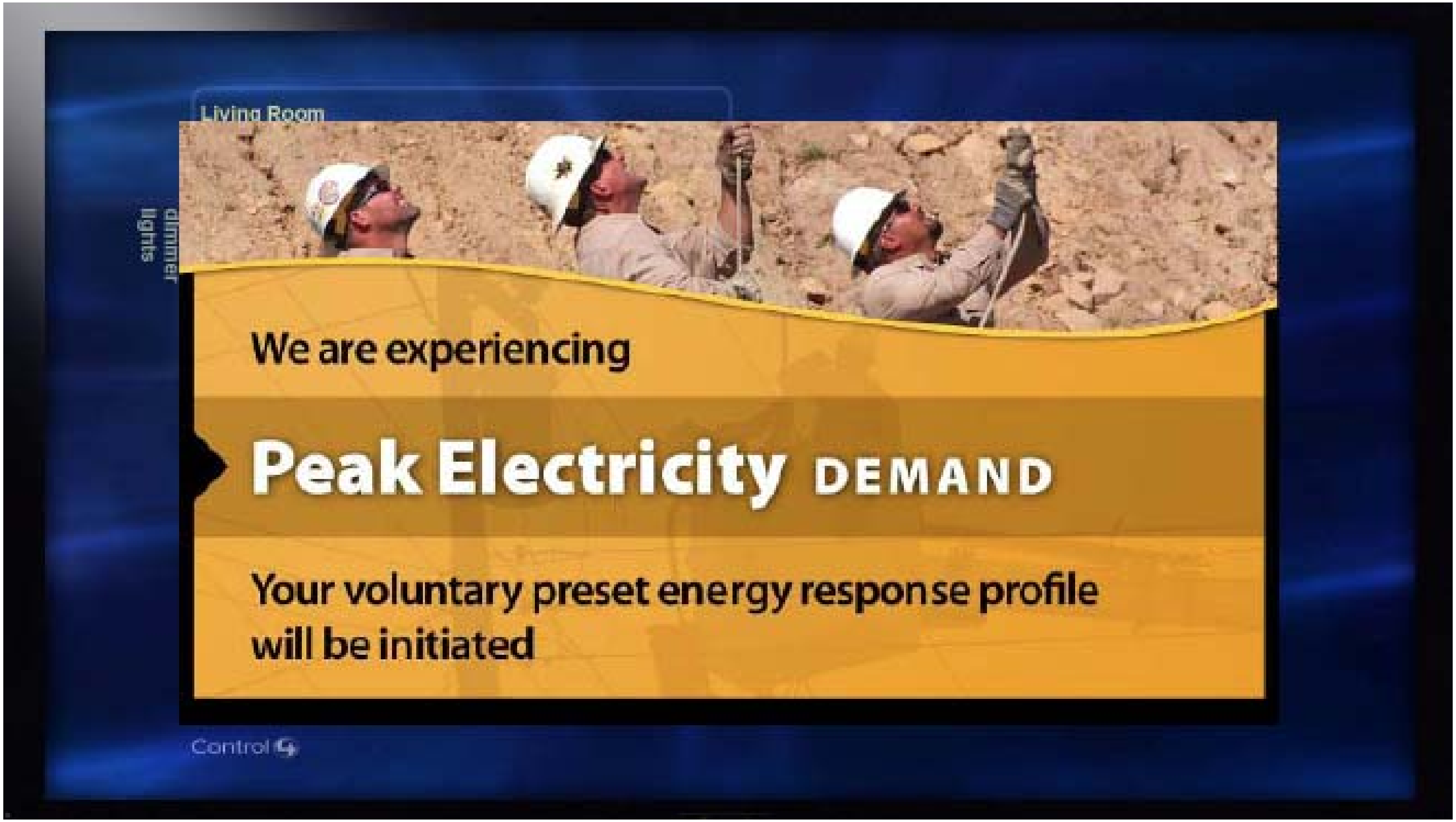

Back
Energy Usage
Current Use
Monthly Use
Energy Use
kWh Energy Usage
2,000
1,500
1,000
500
0
kWh
Previous
Monthly - 3 Months
Next
Control4


Back
Energy Usage
Current Use
Monthly Use
Energy Use
kWh Energy Usage
Heating: 1.3%
Water Heating: 17.8%
Cooling: 29.0%
Cooking: 10.4%
Televisions: 10.1%
Refrigeration: 7.3%
Dryer: 6.4%
Washer: 0.9%
Lighting: 15.8%
Dishwasher: 1.1%
Previous
Energy Use Pie Chart
Next
Control4

Home Owner – Utility Information Portal

Home owner selects how he / she would like the "Maximum Conservation" request to affect their lifestyle

Control4


Living Room
dimmer lights
We are experiencing
Peak Electricity DEMAND
Your voluntary preset energy response profile will be initiated
Control4


dimmer lights
The power system has returned to
Normal
Your home profile will be initiated
Control4

Appliance Manufacturer Perspective: Whirlpool

Perspectives of Whirlpool

- Significant market share of manufacture of heavy duty appliances
  - The 800 pound gorilla

- What will it take for smart appliances to be typical?

Why did Whirlpool invest in energy management research?

- **To reach beyond simple efficiency & explore demand response and time-based pricing**
- **Understand how appliance design could provide value in a smart grid environment utilizing DR, TOU, RTP, CPP, CPR etc**
- **To understand the consumer attitudes and expectations**
- **Learn how we can help residential consumers manage energy in a non-intrusive manner**
- **Need to research both the technology and consumer interactions in the energy managed home.**

Considerations

- **Is there a smart-grid impact on product design?**
- **Greater differences in objectives revealed**
- **The grid vs the utility vs the product manufacturer vs the appliance vs the consumer**
  - **Consumer**
  - **Product manufacturer (e.g. Appliance, HVAC, HW)**
  - **Power utility**
  - **Grid Operators**
  - **Regulators**
- **Consumers, if not appropriately engaged, have been known to thwart a utility program.**

DR Financial Questions

- **Whose money is spend and whose money at risk?**
  - ✓ **Grid / ISO / RTO**
    - **Reliability**
    - **Ancillary services / spinning reserves**
  - ✓ **Utility**
    - **Risk management and avoided cost in open market**
  - ✓ **Consumer**
    - **Purchases the smart-grid enabled product**
    - **Pays the electricity bill**
  - ✓ **Manufacturer**
    - **Additional R&D and manufacturing cost**
    - **Logistic issues in a diverse energy environment**
  - ✓ **Utility Technology Supplier**
    - **Renumerated for equipment designed & installed**

Assurance of return ✓ ✓ ✓

Two Device Categories

Persistent vs. Process-oriented

Single persistent task such as:
- Maintaining room temperature
- Keeping water warm

Start-to-finish process involving multiple steps, sensors, temperatures and consumables often performing the task upon other consumer products such as food, clothing, and dishes.


also refrigerators


also stoves & ovens

--- **<u>Forced power interruption</u>** ---

may be acceptable

limited options

An "*energy-managed appliance*" could be defined as on able to:

- Interpret messages from the utility
- React to conditions of the electricity grid
- Provide value to our appliance consumer that also assists the utility industry and grid operators

Residential Devices

Many individual product sub-categories:

- Air purifiers
- Washers & dryers
- Ovens & ranges
- Countertop appliances
- Dehumidifiers
- Dishwashers
- Fabric fresheners
- Freezers

- Water heaters
- Microwave ovens
- Refrigerators & Ice makers
- Room air conditioners
- Trash compactors
- Television & Cable
- Audio
- Computer, network, broadband

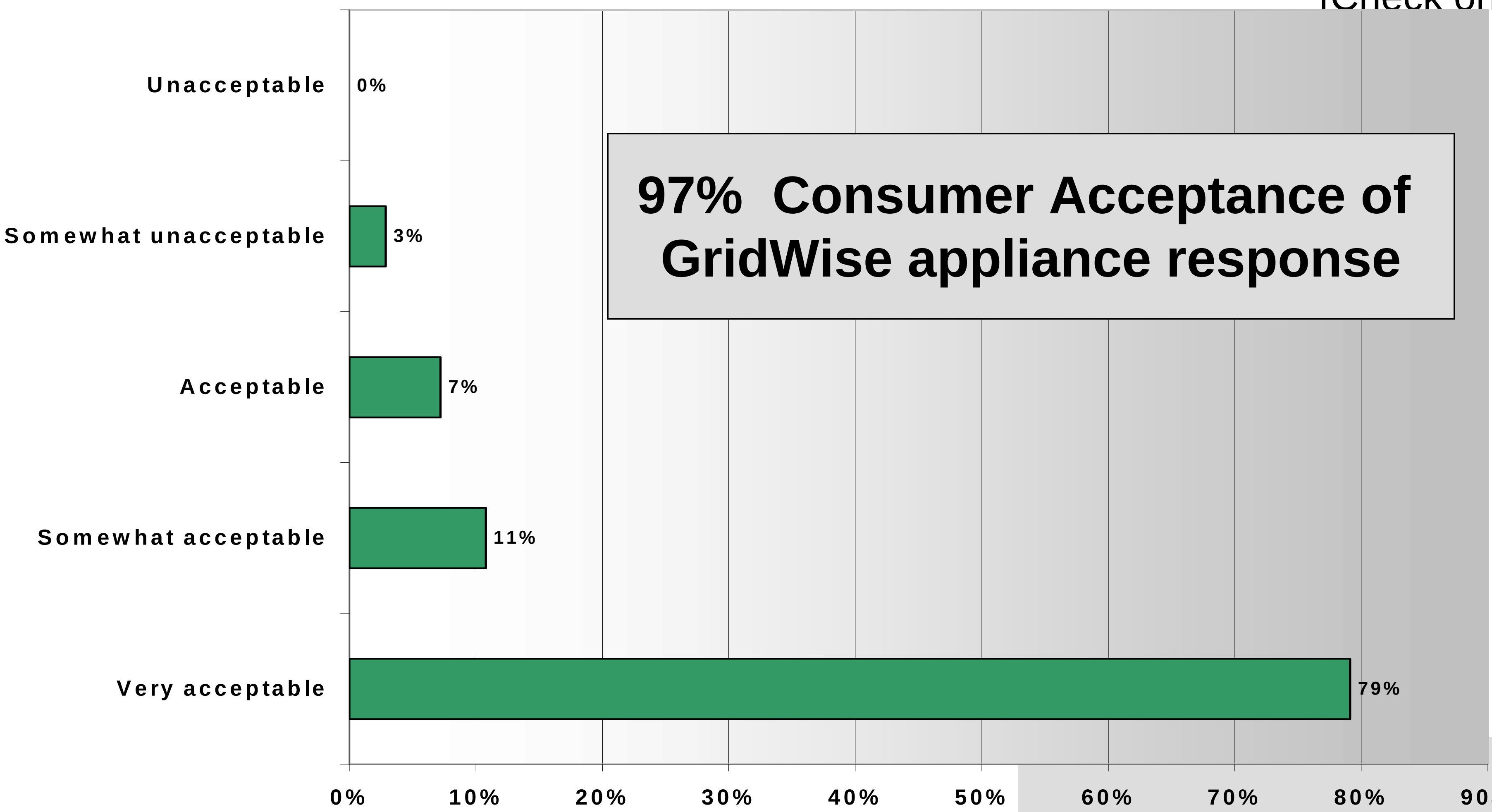
Key Concept:

- **Each device type and model may have a different response depending on components, real-time status, design issues, nature of the request & consumer preferences.**

Consumer Interaction

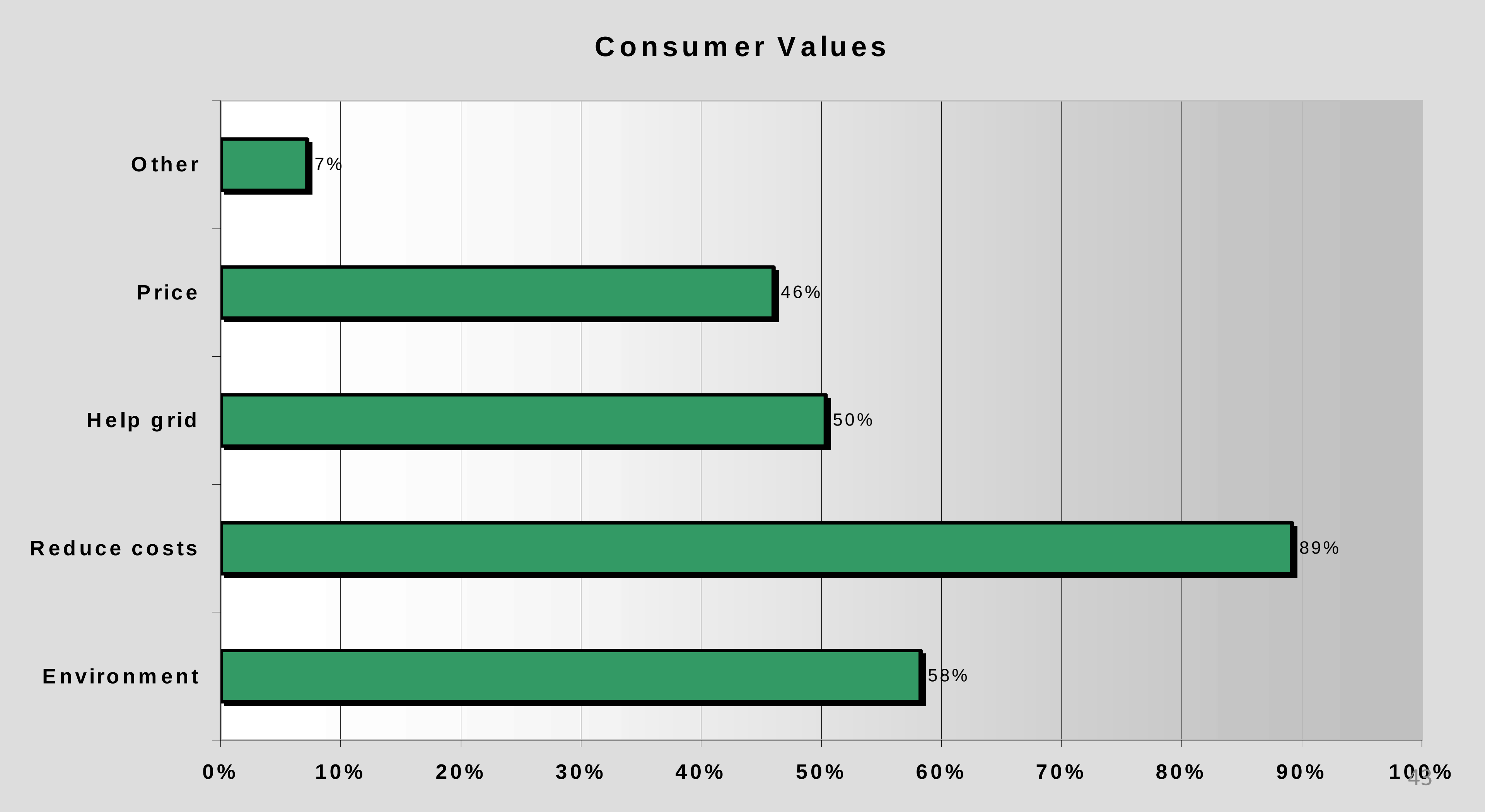
"How acceptable was it to have your clothes dryer cycle run a few minutes longer, occasionally, in response to power grid needs?" [from Post Pilot Survey]

[Check one]



Consumer Interaction

"Which of the following would most strongly influence your decision to purchase a Grid Friendly clothes dryer instead of a standard model? [Check all that apply] [from Post Pilot Survey]



Steps to Realization

- Simplify communications (grid messaging)
- Document messages by objective
- Motivate implementation and commercialization
- Tariffs in plain English in standard format
- Standard way to compute benefits

Enable Understanding:

- Regional differences are extreme
  - Legislative, tariffs, climate, hardware, consumer attitudes, expectations etc …
- How do we compute benefits for the masses?
  - Can we create standard computational format, yet retain regional and utility differences?

Hurdles to Realization

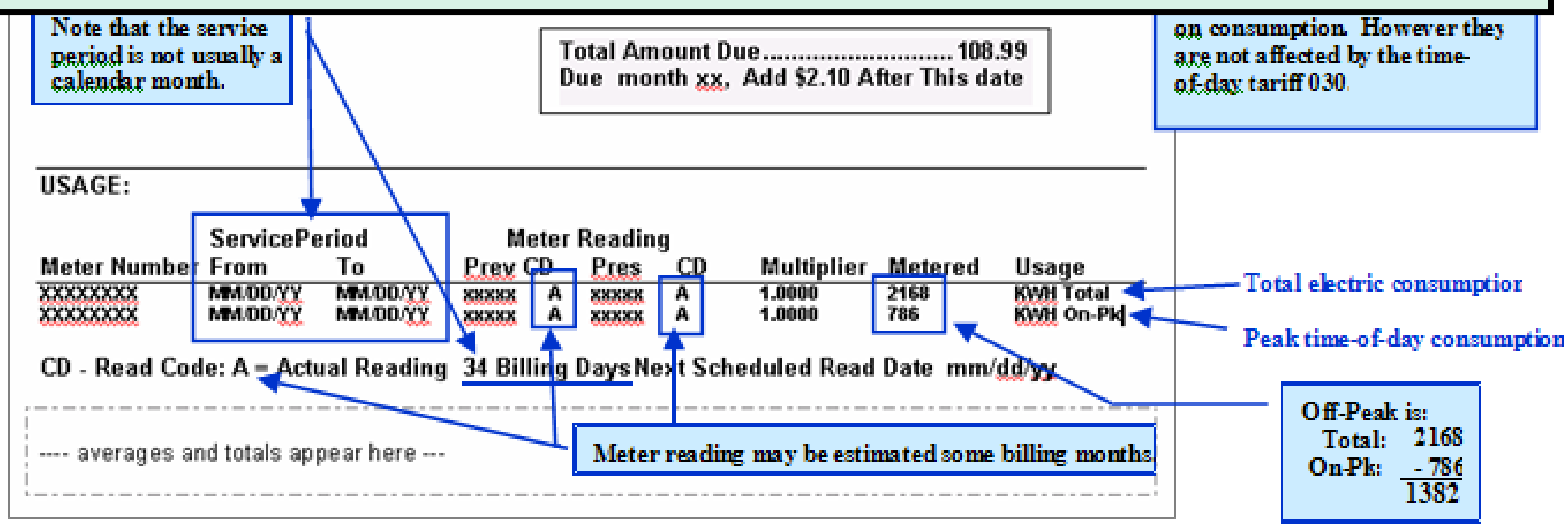
- 4,000+ <u>sets</u> of tariffs to deal with in US & CA
  - Motivation is extremely regional
  - Business case for product manufacturers is very difficult to create and validate
  - Consumer motivation to purchase enabled products
- Determine value of DR
- Ability to show the consumer:
  - why they should participate (education & motivation)
  - convenient participation (painless or un-noticed)
  - how they will benefit (compensation)

Interesting Thought:

- If "<u>penny saved is a penny earned</u>", can we actually <u>spend</u> that penny?

How a consumer thinks:

1. My bill: **$108.99**
2. I used: 2,168 kwh
3. Division = 5.02¢ / kwh
4. How can I conveniently lower <u>all</u> of these?



Steps to Success

- **Tariff design to enable consumers and manufacturer understanding of benefits and business cases.**
- **Quantify value of home / device response**
- **Define objective-based smart-grid messages**
- **Appliance / device manufactures**
  - **determine how their products can respond**
  - **handle the consumer interface relative to their products and consumer preferences**
- **Consumer incentives** (purchase & cost of ownership)
- **Development of a consumer installable DR module**

Interoperability: Why?

- Reduced integration cost
- Reduced operating cost
- Reduced capital IT cost
- Reduced installation, upgrade costs
- Better security
- More choice in products, features, prices

Closing Thought on Whirlpool

- Discussion pointed to a direction where appliance would have a standard (USB?) port into which modules for demand response, maintenance, troubleshooting, etc. would be used.
- In other words, communications to control appliance will be outside appliances with continuously improving functions to control

Commercial Buildings

Characteristics of Commercial Buildings

- Diverse
  - Big buildings attract most interest from vendors
  - All vintages of systems (pneumatic, electric, digital), communications w/ other building systems often incompatible
- First cost is key (so hardware can be tough)
- Customers tend not to churn vendors
- Service contracts, then upgrades
- Biggest focus: HVAC (lighting overlooked)

Typical Functionality - 1

- **Scheduled Start/Stop** – Starting and stopping equipment based upon the time of day, and the day of the week
- **Duty Cycling** – Shutting down equipment for predetermined short periods of time during normal operating hours.
- **Demand Limiting** – Temporarily shedding electrical loads to prevent exceeding a peak value…requires frequent attention
- **Unoccupied Setback** – Lowering the space heating setpoint or raising the space cooling setpoint during unoccupied hours.
- **Warm Up/Cool Down Ventilation & Recirculation** – Controls operation of the Outside Air dampers when the introduction of OA would impose an additional thermal load during warm-up or cool-down cycles prior to occupancy of a building…often poorly executed
- **Hot Deck/Cold Deck Temperature Reset** - Selects the zone/area with the greater heating and cooling requirements, and establishes the minimum hot and cold deck temperature

Typical Functionality - 2

- **Reheat Coil/Reset** – Selects the zone/area with the greatest need for reheat, and establishes the minimum temperature of the heating hot water so that it is just hot enough to meet the reheat needs
- **Chiller &/or Boiler Optimization** – For facilities with multiple chillers &/or boilers, the most efficient units are selected to meet the existing load with minimum demand and or energy
- **Chiller Demand Limiting** – The chiller electrical load is reduced at certain times to meet a maximum pre-specified chiller kW load
- **Lighting Control** – Controls lighting according to a pre-set time schedule
- **Remote Boiler Monitoring and Supervision** – Uses sensors at the boiler to provide inputs to the EMCS for automatic central reporting of alarms, critical operating parameters, and remote shutdown of boilers.
- **Maintenance Management** – Provides a maintenance schedule for utility plants, mechanical and electrical equipment based on run time, calendar, or physical parameters.

Challenges

- The facilities organization:
  - Tends to be short of resources with many responsibilities
  - Rarely understands past, current or future energy markets
  - Lacks the ability to quantify demand reduction
  - Lack the prerogative to execute these strategies if there are potential negative consequences

Demonstration of Demand Response in a Box Store

Key Policy Points

Interoperability

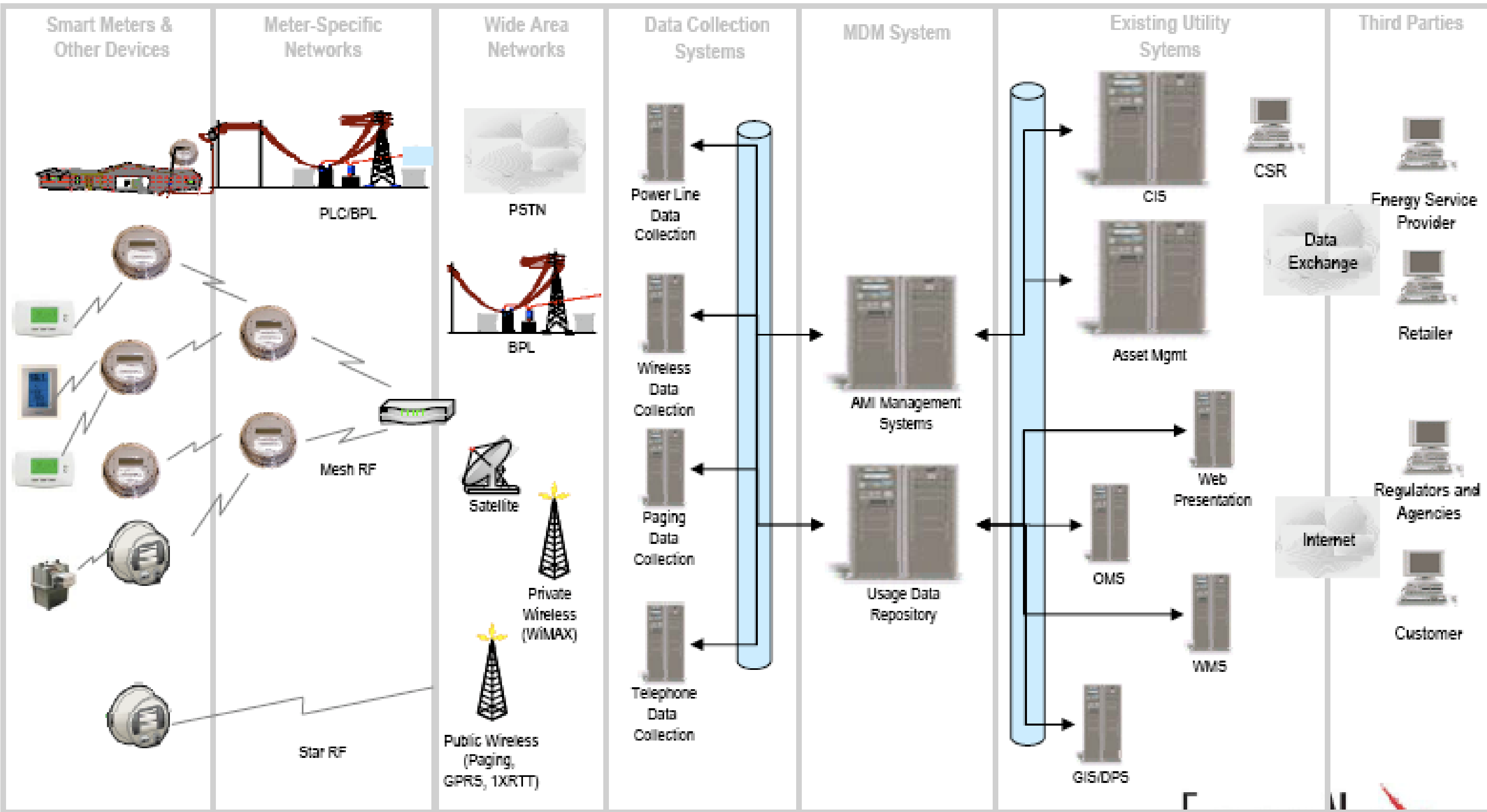
- Diverse systems and organizations working together
- Data exchange, common formats, protocols
- Designed (top-down) interoperability is cheaper and more robust than back-fitted interoperability

Top –Down Interoperability

- Defining opportunities for standards
  - What is technology independent
- Think about purposes (security, network management, legacy adaptation, expansion) at the beginning

AMI/DR System Architecture

Well Defined Points of Interoperability



EnerNex CORPORATION

Barriers to Interoperability

- Inexperience (utilities, suppliers, regulators)
- Incomplete standards
  - And utilities/regulators not demanding them
- Incomplete vision of what is possible
- Hard to make the leap

Hope

- Many are working on this
  - So build on this, don't reinvent the wheel
- Technology is here
- Work needed: Define functionality and value

Gridwise Architecture Council

- Principles
  - Business
  - Usability
  - Information technology
  - Regulatory
  - Governance

Regulatory Principles

- **Context:** Business is conducted under a formal set of rules or laws meant to follow policy guidelines. The rules are set, maintained, and enforced by various local, state, and federal agencies in accordance with their jurisdictions. Business interactions associated with the electric industry are reviewed and monitored by those regulatory bodies whose role is to ensure a viable electric system environment that supports our economy and balances issues of social equity.

- **R01**- Interoperability strategies and issues must be communicated in a form to be understood by regulators and policy makers.
- **R02**- Interoperability approaches among organizations must allow regulators the ability to verify that business is conducted within established rules and that all relevant transactions are auditable.

Interoperability Checklist

- People don’t understand interoperability
- Decision-makers don’t understand how to recognize and implement interoperability
- Easy is good. Short and Easy is better.
- The more people make decisions affecting the grid with interoperability in mind, the faster we’ll get to a smarter grid
- A way to get started – always more details

What’s In The Checklist

- Architecture and Design
- Interconnectivity and security
- Evolutionary capability
- Collaborator independence

Checklist Detail

- Points of interface
- Open architecture
- Tech neutrality & functionality specs
- Use multiple vendors
- Open standards
- Connectivity & information exchange
- Standard comm/data
- Key data availability
- Common info feed controls multiple pts
- Privacy/security
- Redundancy/failsafe
- Upgrade via download
- Backward compatible
- Latitude for independent choices

And there is a Scorecard from Smart Grid News

Quality	Criteria	Score
Impact	*Does it make the power system more reliable, efficient, predictive or interactive?*	
Openness	*Is the technology freely and widely available?*	
Standardization	*Are the interfaces defined according to recognized standards?*	
Security	*Does it protect critical information and manage who is authorized to access it?*	
Manageability	*Does it permit the monitoring and control of performance, configuration, health, accounting, and security?*	
Upgradeability	*Does it permit adding, changing or improving key features later?*	
Scalability	*Does it permit future expansion?*	
Extensibility	*Does it make it easier to integrate new devices and applications?*	
Cost-Effective	*Does it add measurable business value to the organization using it?*	
Self-Healing	*Does it recover automatically from failures?*	
Interactivity	*Does it help the grid and its users react to each others' needs?*	

Quality	Criteria	Yes/No
Impact	***Does it make the power system more reliable, efficient, predictive or interactive?***	
	Improves power system wide-area reliability	
	Improves power system efficiency and optimization	
	Improves prediction and simulation of power system operation	
	Improves matching of power supply with demand, e.g. markets	
	Improves consumer participation in the power system	
Openness	***Is the technology freely and widely available?***	
	Intended to encourage communication between devices and systems	
	Interface specifications are published	
	Interface specifications are implemented by multiple (many) vendors	
	Interface specifications are reviewed and updated by users	
	Can be deployed without using or revealing proprietary intellectual property	

Standardization	***Are the interfaces defined according to recognized standards?***	
	Uses standards recognized by industry	
	Uses standards recognized by a national body	
	Uses standards recognized by an international body	
	Is certified by an independent organization	
	Is certified according to standardized test procedures	
Security	***Does it protect critical information and manage who is authorized to access it?***	
	Authenticates and authorizes users according to their roles	
	Protects consumer, business and operational information	
	Detects attacks and intrusions	
	Permits centralized management of security credentials	
	Permits logging and auditing of important operations	

Manageability	***Does it permit the monitoring and control of performance, configuration, health, accounting, and security?***	
	Permits or performs remote determination of health	
	Permits or performs remote enable/disable of devices or functions	
	Permits or performs time synchronization sufficient for application	
	Reports or gathers operational and communications statistics	
	Reports or gathers alerts and warnings	
Upgradeability	***Does it permit adding, changing or improving key features later?***	
	Permits remote download of software or firmware	
	Permits remote download of configuration, features, or settings	
	Permits remotely changing security algorithms and credentials	
	Permits remotely changing communications technology	
	Integrates well with older versions	

Scalability	***Does it permit future expansion?***	
	Contains no fixed limits on growth	
	Permits and encourages configuration version control	
	Can be deployed at millions of sites	
	Co-exists with or improves legacy systems	
	Can be deployed at a variety of locations in the power system	
Extensibility	***Does it make it easier to integrate new devices and applications?***	
	Automatically detects changes in topology or configuration settings	
	Designed in small modules with standardized interfaces	
	Publishes or describes what data and services are available	
	Shares a standardized information model across the system	
	Separates definition of information from how it is transported	
Cost-Effective	***Does it add measurable business value to the organization using it?***	
	Has well-defined and published performance standards	
	Has been tested to performance standards	
	Reduces installation or maintenance costs	
	Reduces operational costs	
	Enables new businesses, products or services	

Self-Healing	***Does it recover automatically from failures?***	
	Operates during power outages	
	Permits or performs automatic choice of communications path	
	Integrates communications and power system failure management	
	Encourages distributed decision-making close to the point of impact	
	Encourages wide-area coordination and recovery from failures	
Interactivity	***Does it help the grid and its users react to each others' needs?***	
	Encourages consumer awareness of energy usage	
	Creates new choices for consumers	
	Encourages participation in energy markets	
	Minimizes visibility of technology	
	Permits exceptions and special cases	

Erich's Concluding Thoughts to Regulators

- Focus on defining desired functionality
- Communicate policy goals clearly
- Develop technology independent architecture
- Consider path of system evolution
  - Optimize locally first, global can follow
- Use ways to objectively evaluate
- Be aware of progress already achieved

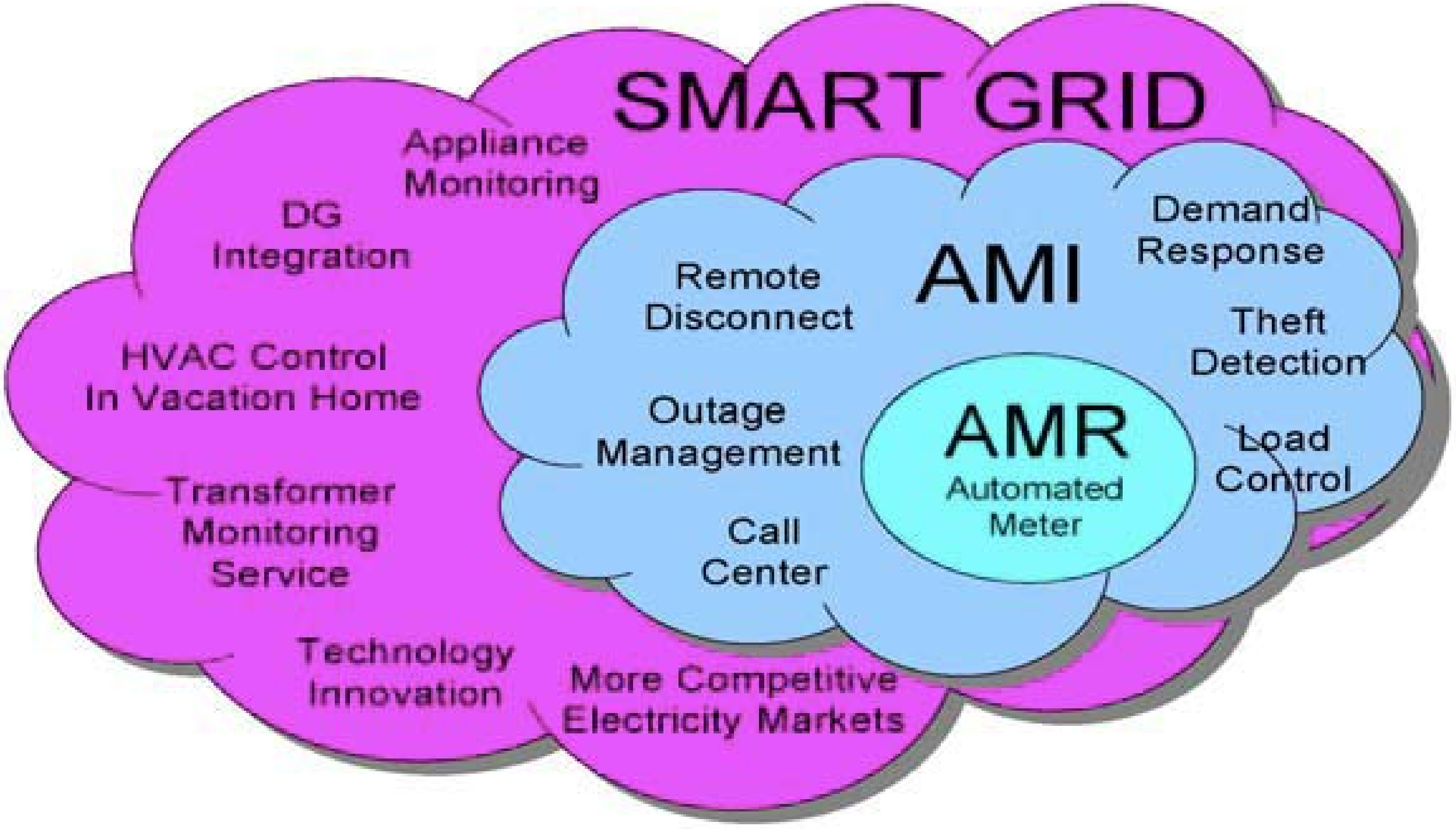
Chris' Closing Thoughts for Regulators

- Market transformation takes time
- Incentives for transition are useful, but market consistency is most important
- Education and simplicity are critical
- System is only as good as people in the system

Recommended Resources

- http://www.gridwiseac.org/pdfs/gwac_decisionmakerchecklist.pdf
- http://www.ucop.edu/ciee/dretd/documents/pier_dr_sumrprt.pdf
- http://www.smartgridnews.com/pdf/Smart_Grid_Scorecard.pdf
- http://my.epri.com/portal/server.pt?Abstract_id=000000000001013610

Regional Approach to Smart Grid?



Possible Objectives

- Make sure discussions are at the highest level
- Making useful information available where it is most useful
  - Info on individual HVAC system: useful to HVAC vendor, not so useful for utility

Key Regulatory Considerations

- Functional (minimum) Requirements
- Interoperability
- Technical Standards (comm protocols)
- Collecting, Managing, Accessing Data

One set of functional requirements (BGE)

- Automate meter reading
- Two-way communications
- Remote disconnect at or below 200 amps
- Hourly data once per day
- Time stamp meter data
- Data to customer on day after basis
- Data storage at meter
- Outage management

- Remote programming
- Bi-directional metering
- Net Metering
- Voltage monitoring
- On-demand data access
- Data security
- Meter tampering detection
- Support local display

Regional Approach to Smart Grid

- Supplement PJM Activity with MADRI subgroup meetings
  - Address issues emerging in the states and provide support, promote consistency
- Identify missing pieces
- Map a plan of action