IoT for Zero Net Energy Buildings
(Leveraging IoT to get to ground zero)

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All new residential construction in California will be zero net energy by 2020.
All new commercial construction in California will be zero net energy by 2030.

What is "Zero Net Energy"

"The societal value of energy consumed by the building over the course of a typical year is less than or equal to the societal value of the on-site renewable energy generated"

--IEPR Workshop on the Definition of ZNE, July 2013

Includes time dependent valuation of energy.

Biggest impact on ZNE buildings

✧ **Building design**
Energy efficient, energy flexible buildings

✧ **Energy harvesting**
On-site generation of sustainable energy

✧ **Energy management**
Smart control of energy usage to optimize "societal value"

Home Energy Manager
The central nervous system for the net zero energy home helps homeowners optimize energy consumption.

Solar Photovotaic
3 kW to 4 kW solar array on the roof to meet energy requirements of the home.

Small Wind
Supplementary renewable generation.

Smart Meter
A communication gateway between the Smart Grid and the home.

Energy Efficient Lighting
High efficiency CFL, LED and OLED lighting.

Geothermal Heat Pumps
Reduces HVAC and water heating energy requirements by 30%.

Demand Response Appliances
High efficiency Energy Star Appliances shed load from the grid and help consumers save money during peak demand.

GE Heat Pump Water Heater
Uses less than half the energy of a conventional electric water heater.

Energy Storage
Battery storage for backup power and peak loads.

GE Water Filtration
Filters, conditions and monitors home water usage.

imagination at work

Building design: *Energy efficient, energy flexible buildings*

Energy harvesting: *Onsite energy production, solar, thermal, wind, etc.*

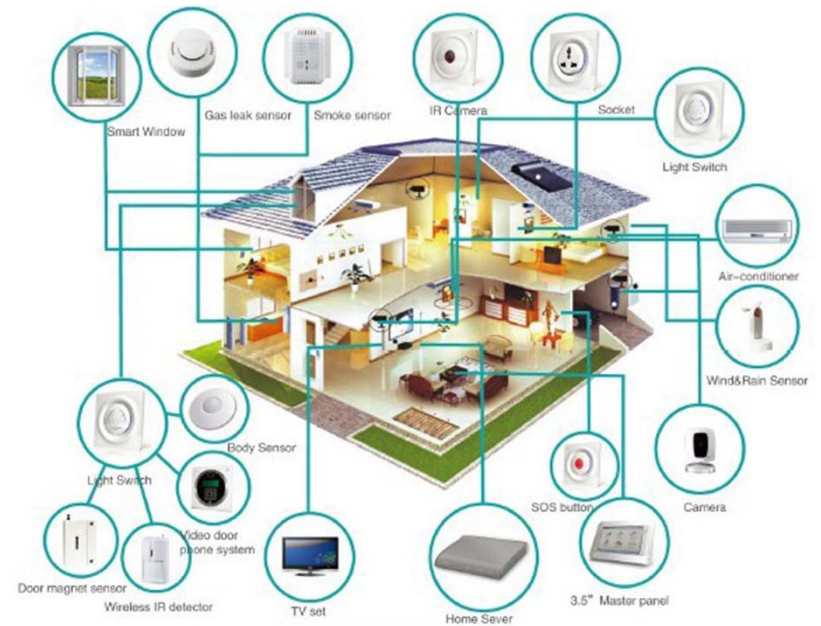Energy management: *Smart control of energy usage*

Times are changing...

Today:
The Internet of People
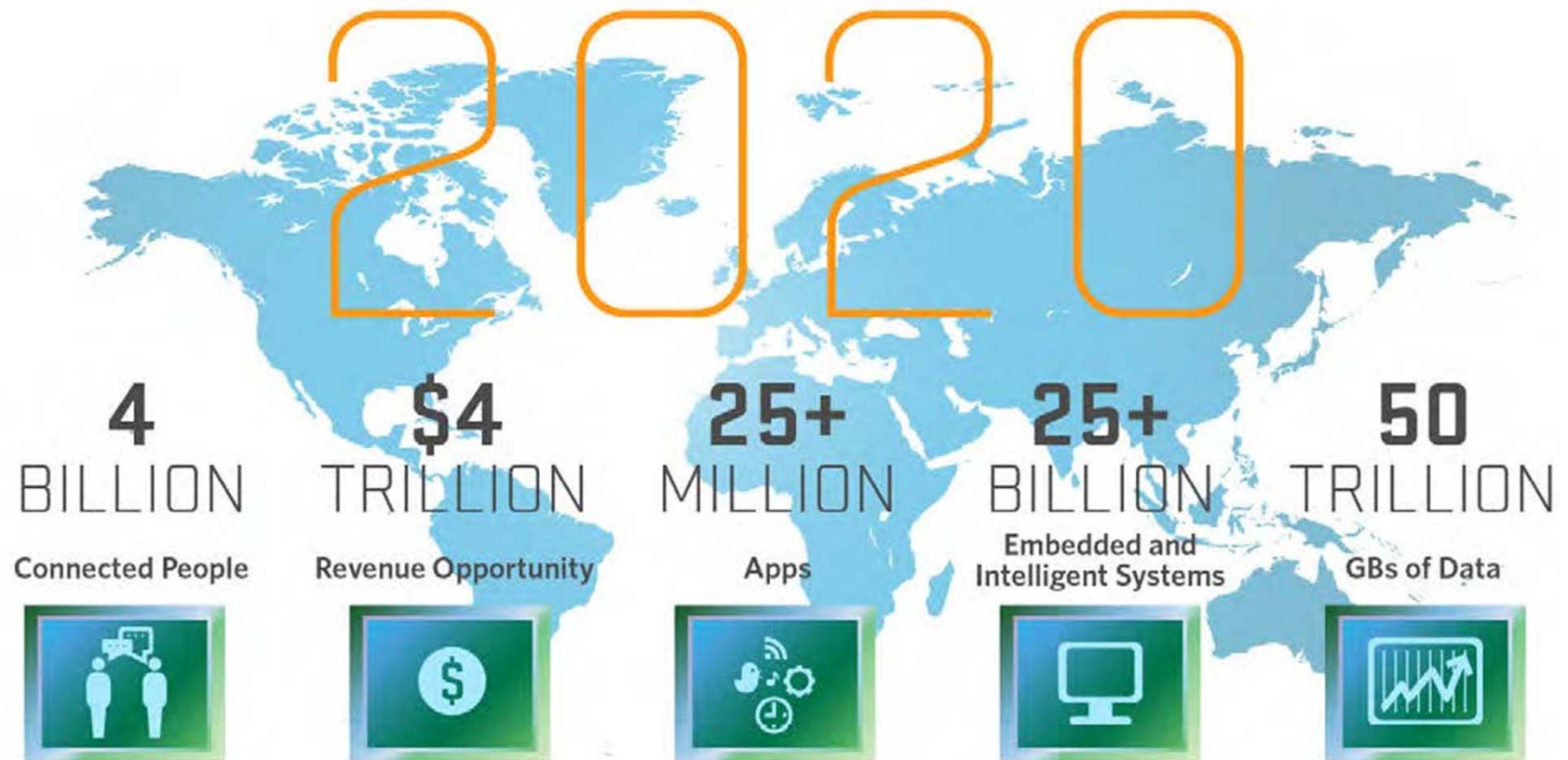Most data generated by/for **humans**

Tomorrow:
The Internet of Things
Most data generated by/for **things**

The Internet of Things

2020

4 BILLION	$4 TRILLION	25+ MILLION	25+ BILLION	50 TRILLION
Connected People	Revenue Opportunity	Apps	Embedded and Intelligent Systems	GBs of Data

Demand Response

Image source: FlexAlert.org, October 2014

When a Flex Alert is called, take three simple actions:

- Turn off all unnecessary lights
- Postpone using major appliances until after 6 p.m.
- Turn your air conditioning thermostat up to 78° or higher

More Energy Saving Tips

Watch how the power of community can make the difference.

Demand Response

Human powered energy management
- Humans view data, make decisions, perform actions
- Slow, inefficient, subject to errors

Automated Demand Response
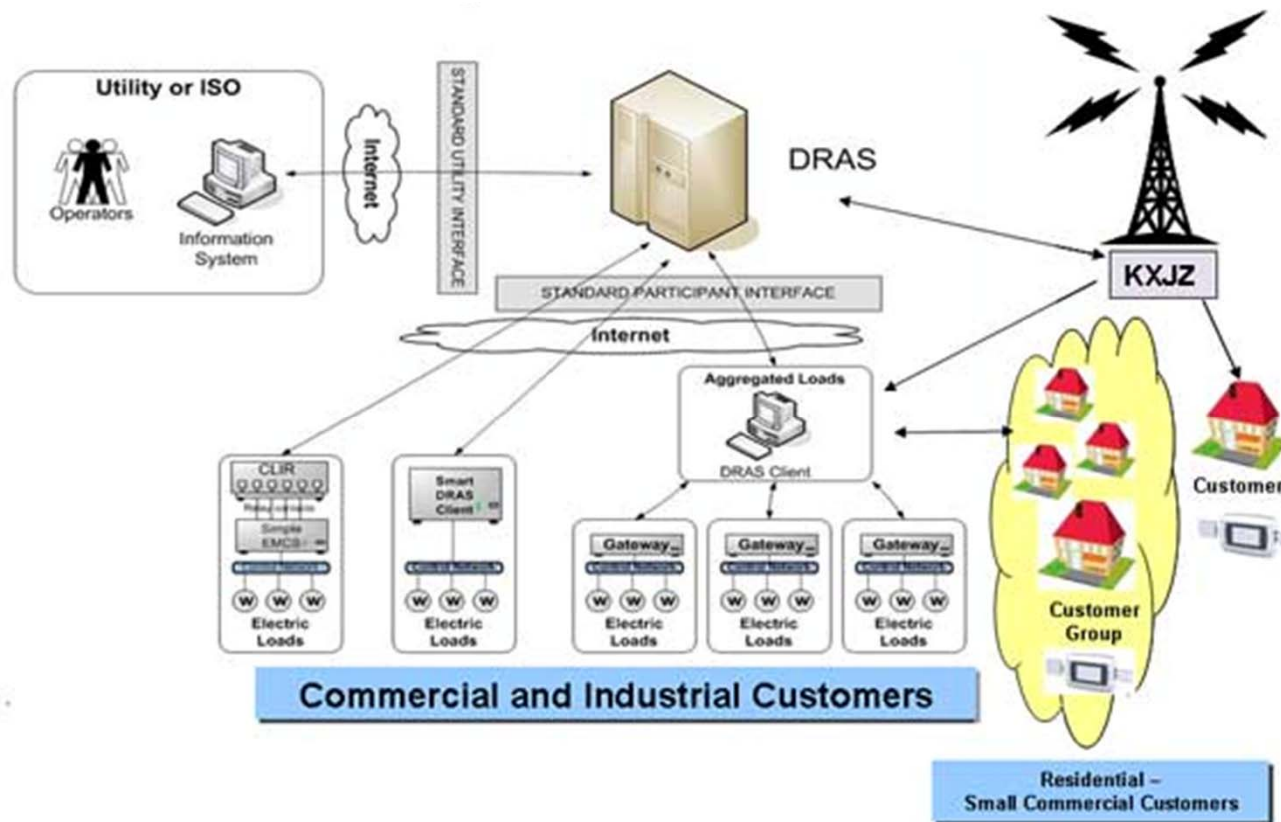
Image source: Demand Response Research Center, LBNL, April 2011

ADR in the cloud
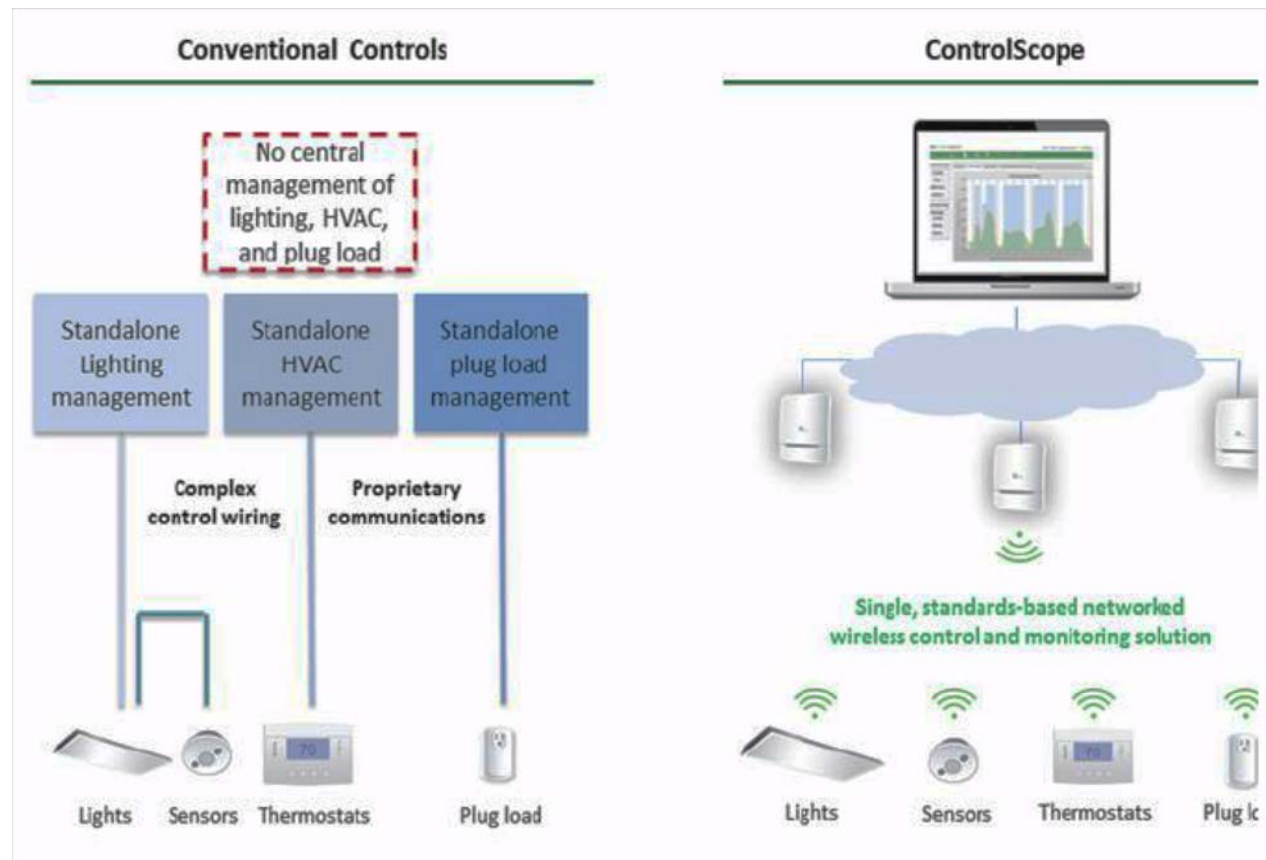
Image source: DaintreeNetworks, November 2013

ADR is not enough (even in cloud). Need more!

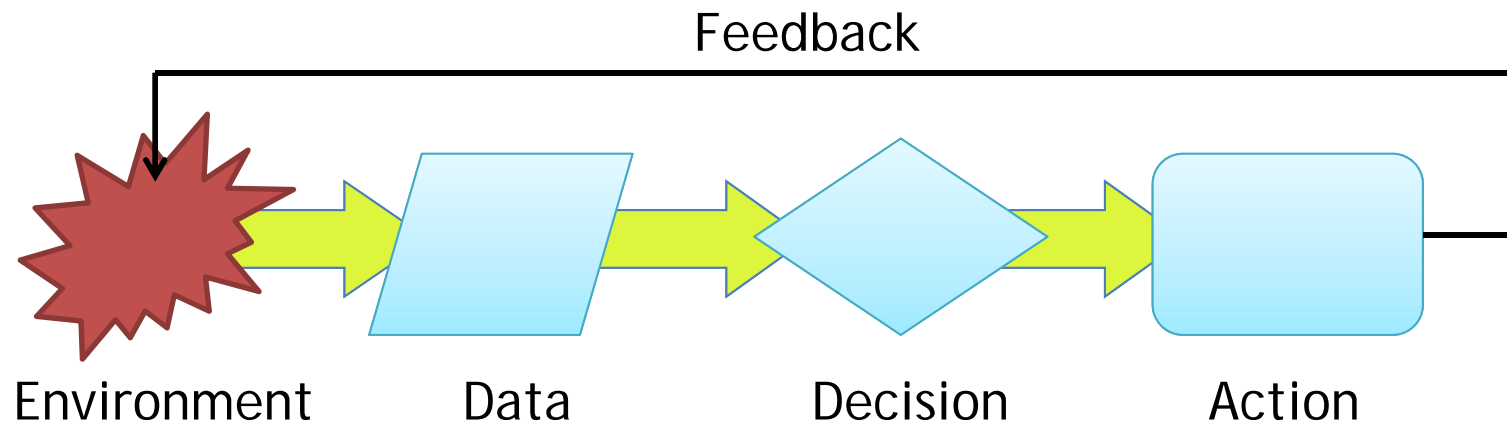**Smart building / site needs to know:**
Which section should respond?
Which energy system should respond?
In which way should it respond?
How long should it respond?
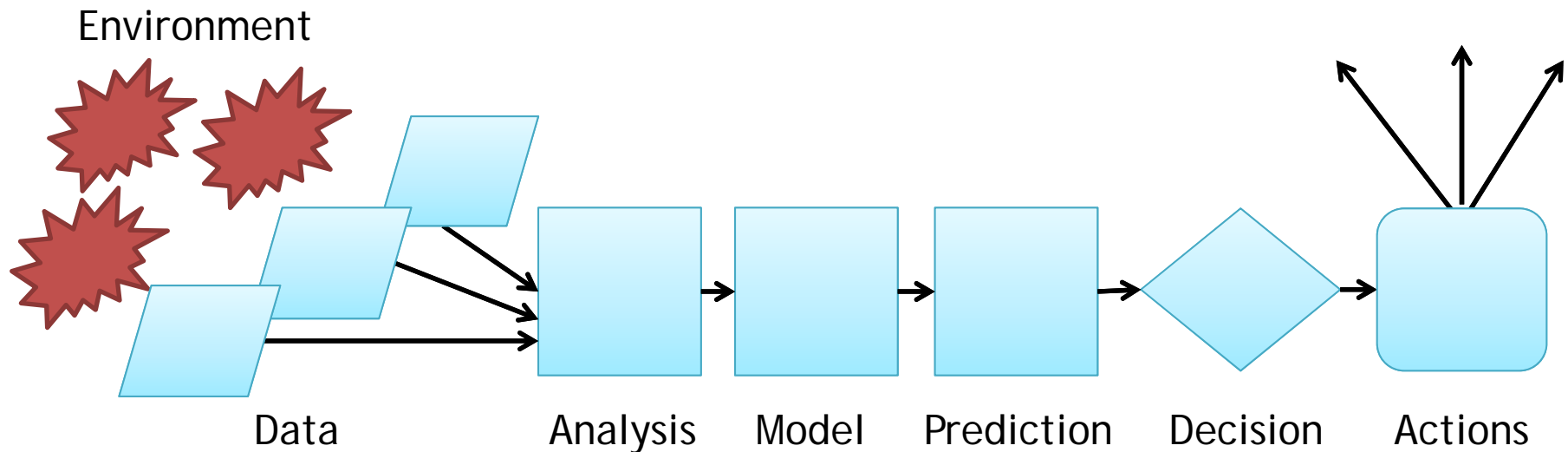
It's not just about remotely turning light bulbs on and off!

Conventional automation approaches are reactive

Feedback

Environment → Data → Decision → Action

Conventional automation feedback system
Does not optimize large scale, complex, multivariate system

IoT enables anticipatory, complex, large scale optimization.

IoT uses post-time and real-time data with analytics, modeling,
and large scale optimization
Allows for much higher level of optimization

IoT allows large scale optimization

IoT uses post-time and real-time data with analytics, modeling, and large scale optimization

Allows for high level of optimization in a complex, multivariate system.

IoT and Big Data, advanced energy management

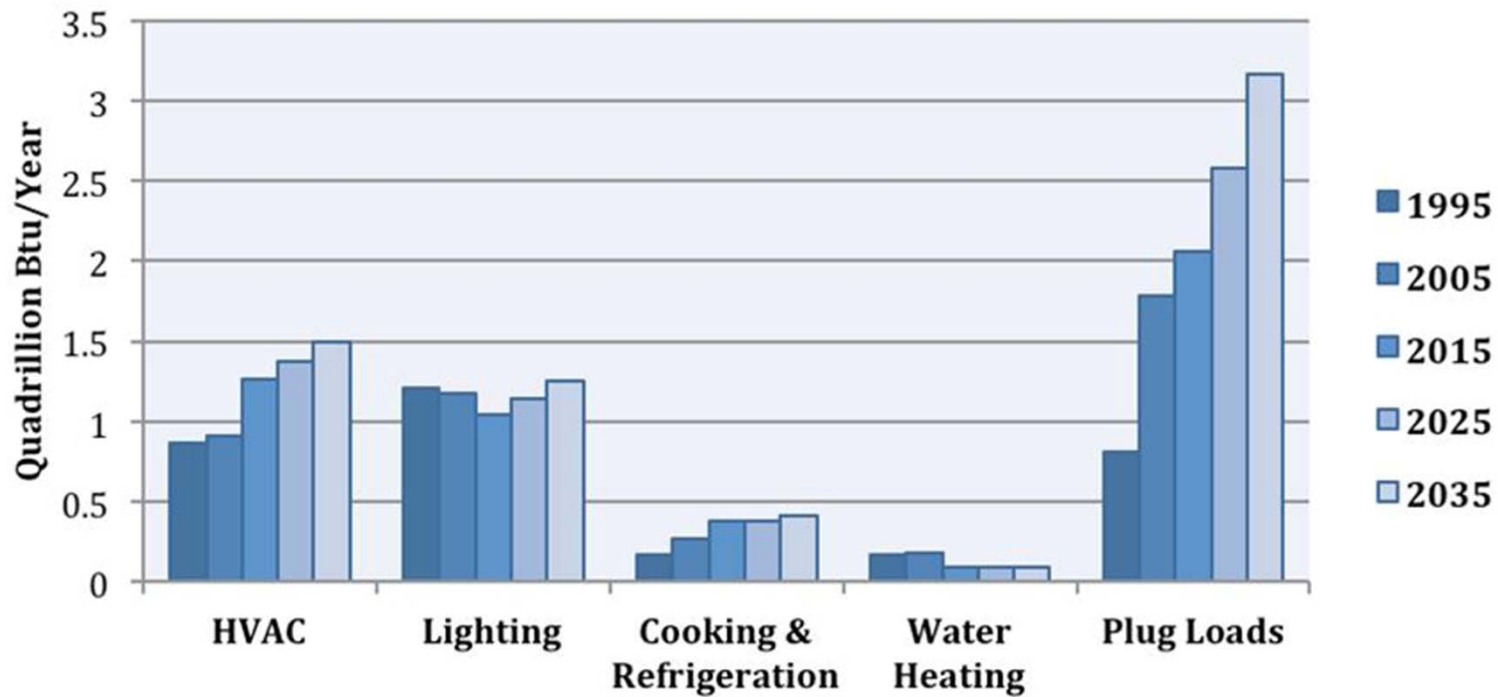**Electricity use breakdown for commercial buildings**

Image source: GreenBiz.com, May 2012

Plug-load monitoring and control

Available technologies

- ✧ On board monitoring
  Data logging / reporting

- ✧ Sensor controlled
  Built in occupancy/vacancy sensors
  Power monitoring

- ✧ Programmed control
  Timer, state-based, threshold controls

- ✧ Wireless control
  May communicate with external controller

Using data to modify consumer energy behavior

Studies indicate that providing households with contextualized feedback and targeted energy-saving tips holds the potential for large scale energy savings, in the range of 4-12% (Ehrhardt-Martinez et al 2010).
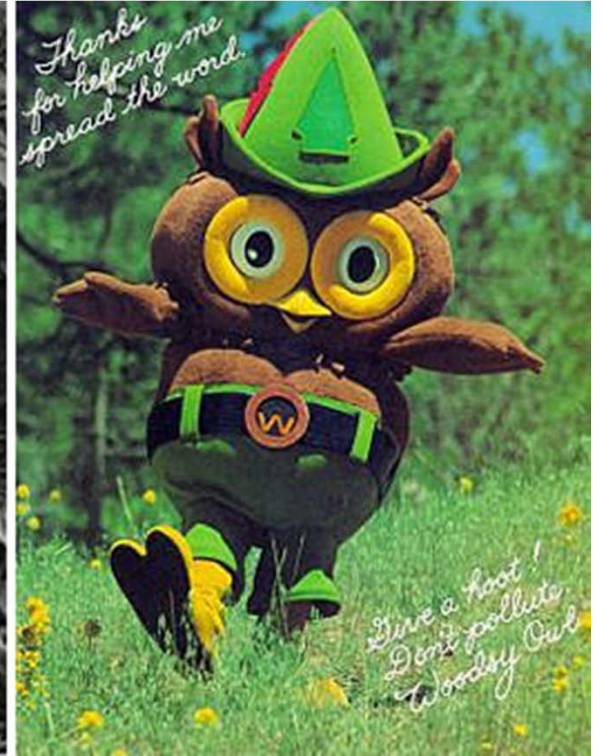
Image source: EveryDayGreen, April 2014

IoT for Zero Net Energy

IoT can play a significant role in moving us to ZNE
- More monitoring, data, and analysis leads to smarter use of energy
- As complexity scales, IoT becomes increasingly more powerful

Remember these days?

Is sustainability just a childhood dream?

Thank you

Contact Information

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