Empowering Personal Energy Management

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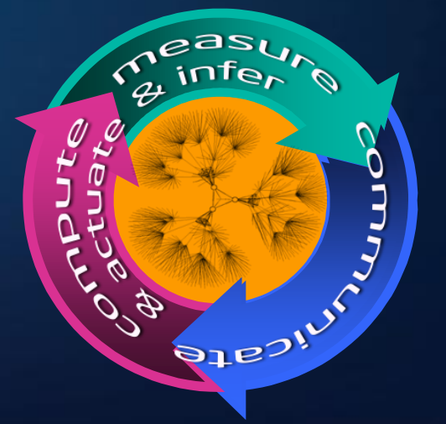
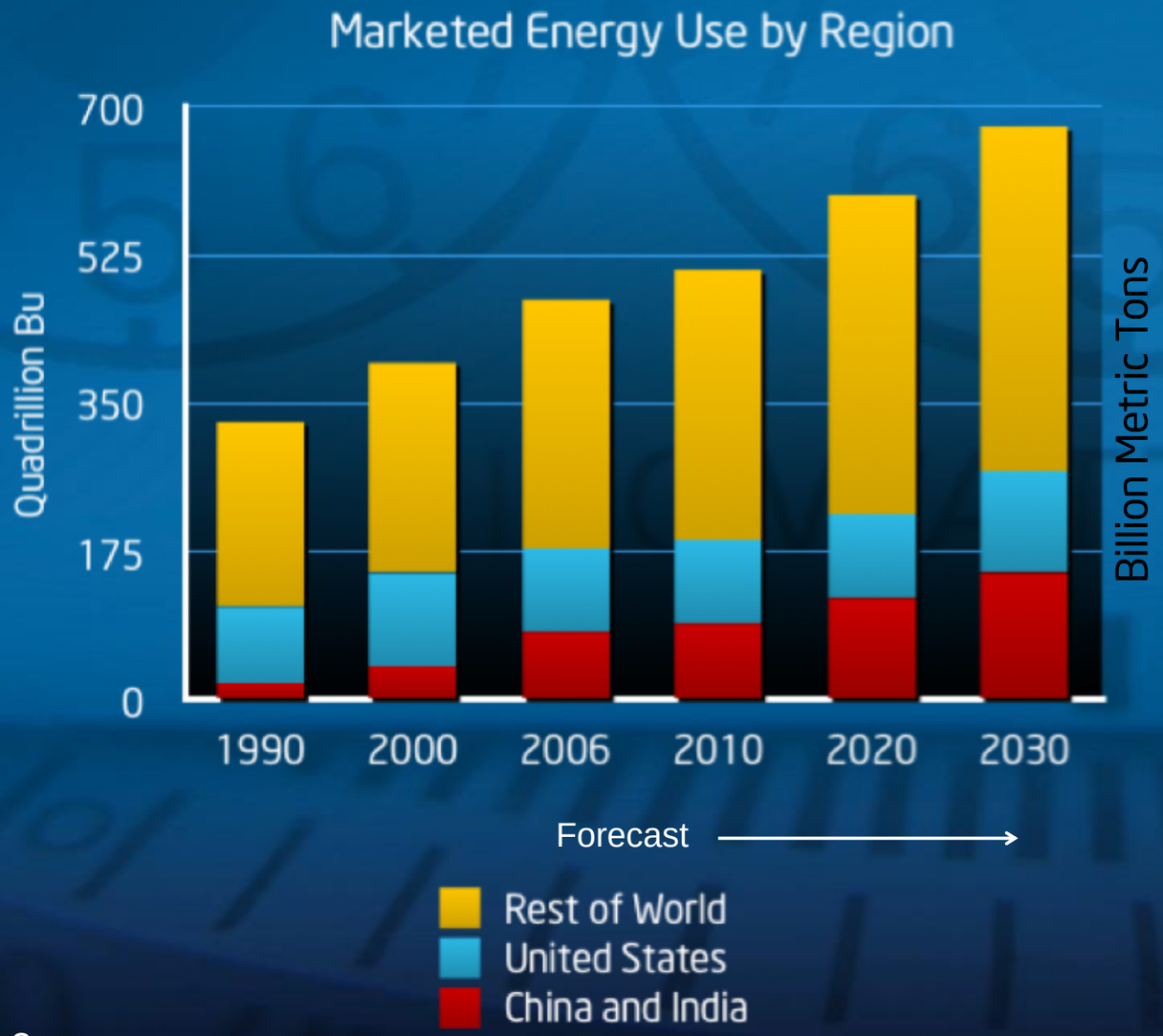
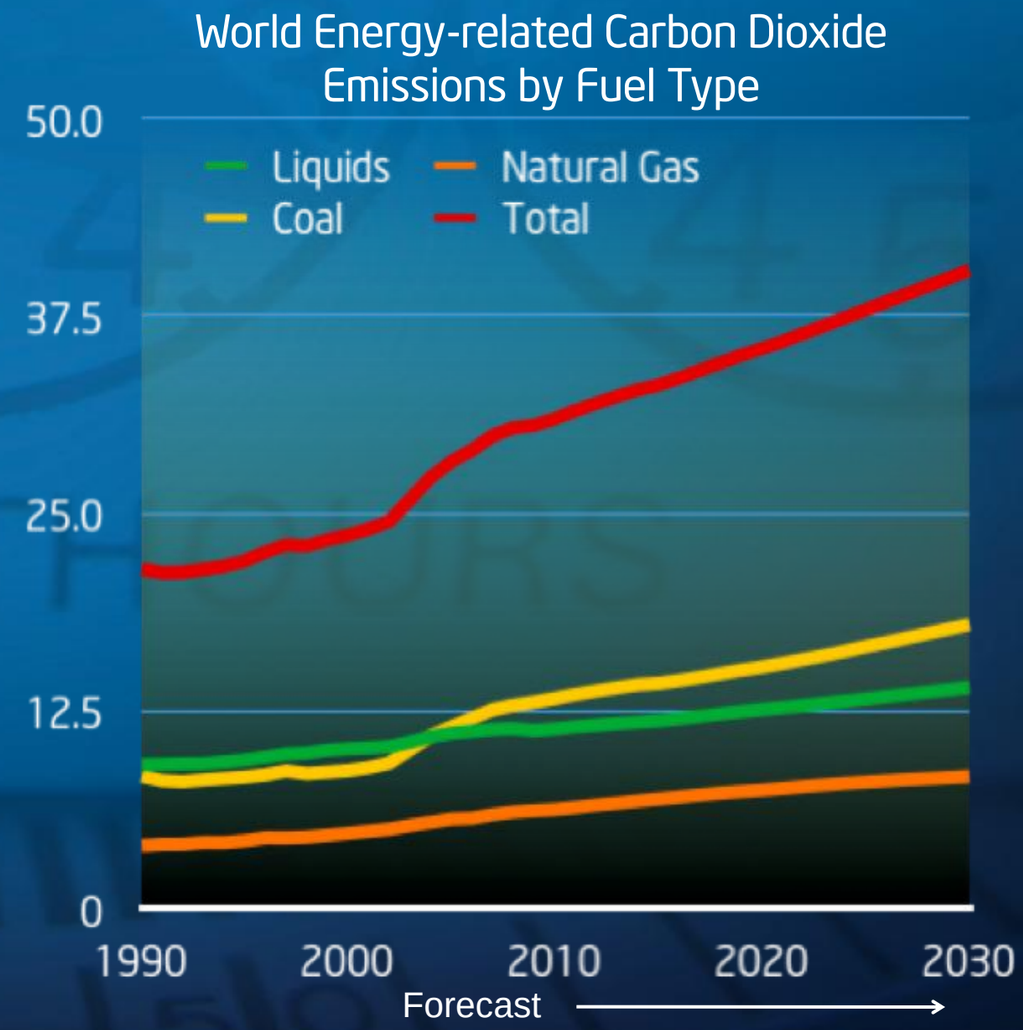


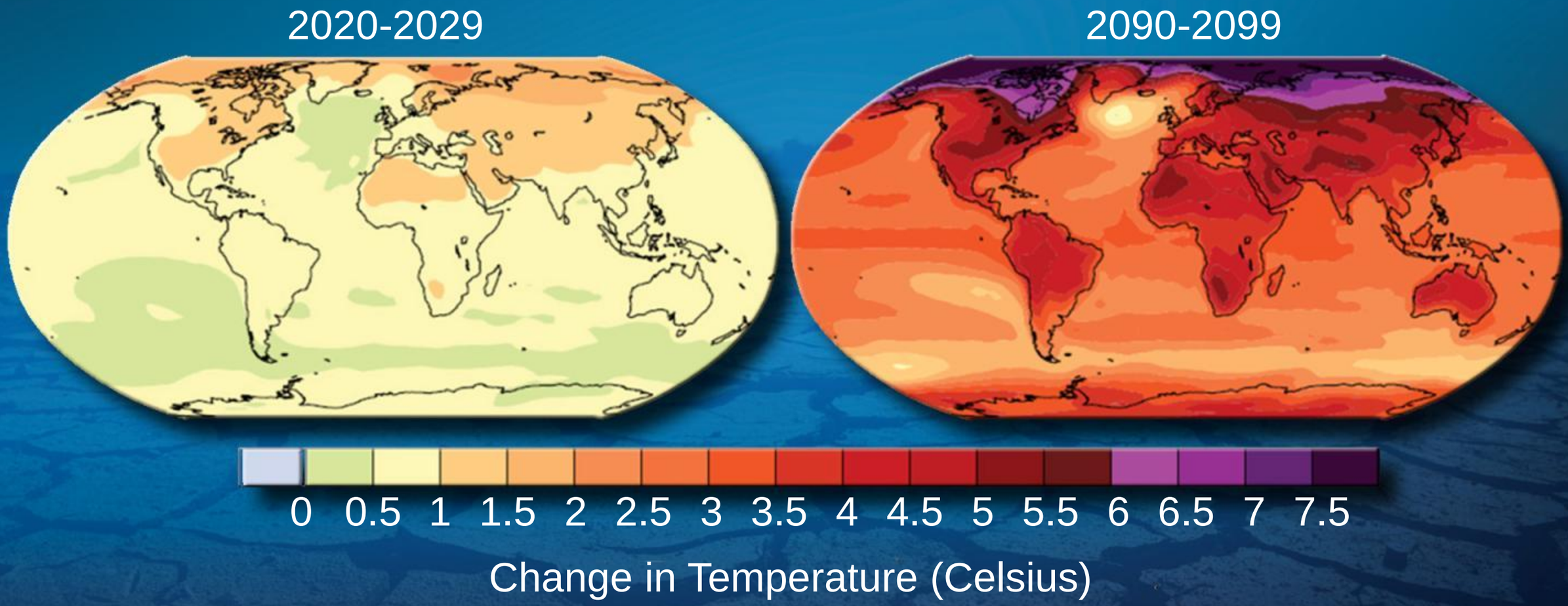
Energy Demand Drives Greenhouse Gases





Source: Energy information administration (EIA), International Energy Annual 2006 (June-December 2008). www.eia.doe.goviea. Projections: EIA, World Energy Projections Plus (2009)

Growing Impact of Greenhouse Gas Emissions



Source: Intergovernmental Panel on Climate Change (IPCC, 2007, Figure WGI-SPM-6)

The Need for Action is Clear

Modernizing the Infrastructure: Smart Grid

While improved infrastructure is important,

energy consumers are just as important

The Impact of Consumers: United States

US Households: 113 Million

US Automobiles: 250 Million

Represent 35% of US Energy Consumption Portfolio

Source: Energy information administration (EIA), International Energy Annual Review 2007. www.eia.doe.gov

The Impact of Consumers: EU

EU Households: 198 Million*

EU Automobiles: 230 Million *

Represent 37% of EU 27 Gross Energy Consumption Portfolio

* Eurostat database: http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/main_tables

How can we use the power of consumers to change how we manage energy?

Slicing the Worldwide Energy Efficiency Opportunity

Drive Computing to Be More Energy Efficient

2%*

Opportunity

Help the World to Be More Energy Efficient

98%

The Big Opportunity

*Source: Gartner, 2007

Personal Computing Empowered the Consumer

30 Years Ago, Computing Was Far Less Personal

Far Away From Users

Not Easily Accessible

Professionals Did It

Today, Computing Is Always At Our Fingertips

Everywhere We Go

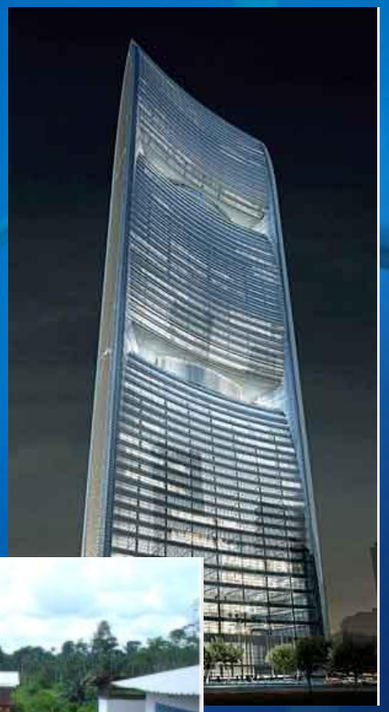
Part of Our Lives

Everyone Does It

From Smart Grid to Personal Energy Management

Focus on Consumers of Energy

- Use technology to inform consumers and change their energy use behavior
- Aggregate millions of small contributions
- Drive a significant change in CO_2 output



Impact of Empowering Consumers

Average US household could:

- Reduce energy consumption by 15-31%

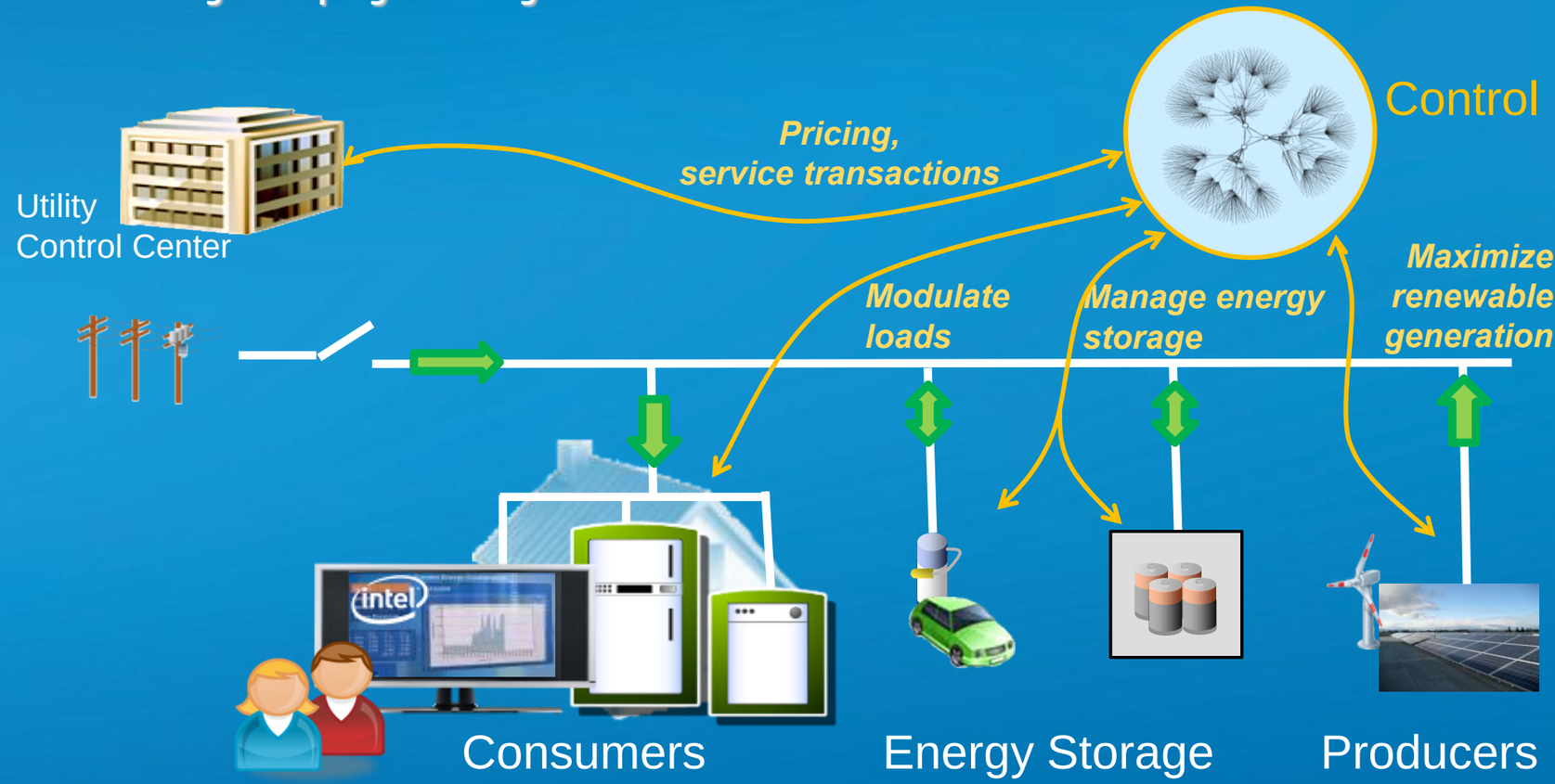
What if 1% of US households realized this savings?

- Reduce annual coal demand by 371,000 tons
- Eliminate need for two 675 MW coal-fired peak power plants
- Reduce carbon emissions by 2.4 million metric tons
- Equivalent of taking 535,000 cars off the road

Source: "Next Generation Home Energy Management Systems – A Mass Deployment Impact", Wipro Consulting Services, September 2009

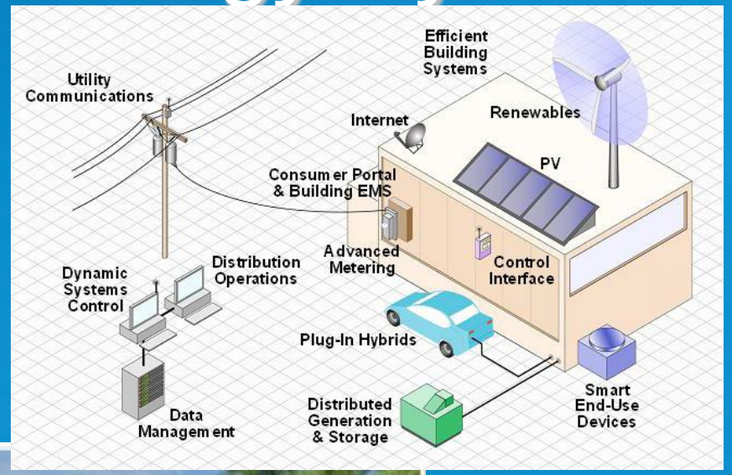
Personal Energy Systems

- Local (Consumers + Producers + Energy Storage + Control)
  - May have ability to operate independently from main grid (if grid-tied)
  - Cyber-physical system

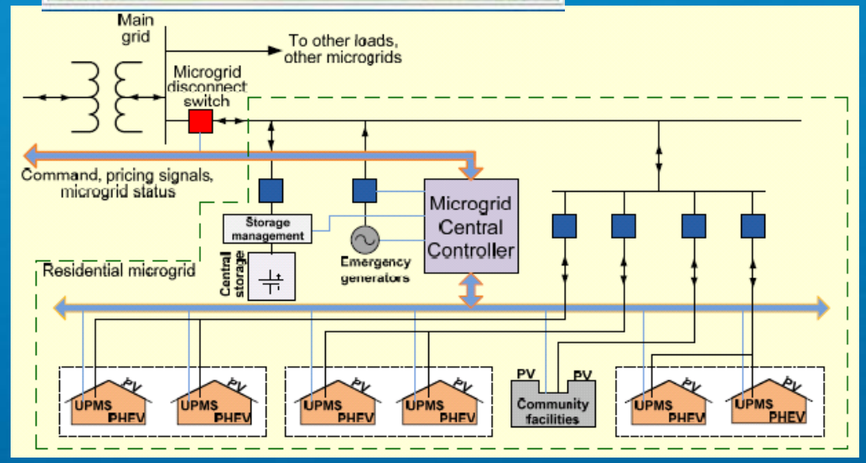


Examples of Personal Energy Systems

- Homes
  - Unmanaged collection of devices
  - Small number of people/devices
- Office buildings
  - IT managed devices
  - Integration with Building Management System
  - Order of magnitude more people to deal with
- Community/Campus microgrids
  - Collection of buildings
  - Private/public data management
  - Higher level aggregation
  - Developed & developing economies



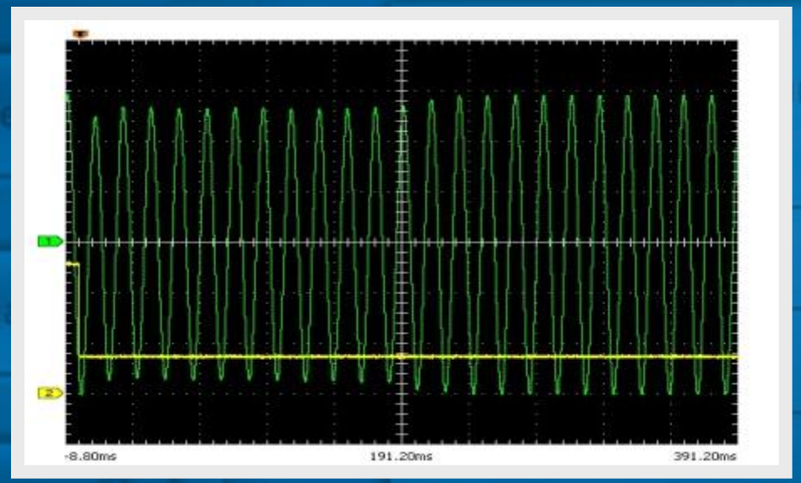
Source : EPRI



Source : Prof. R. Ayyanar, Arizona State Univ.

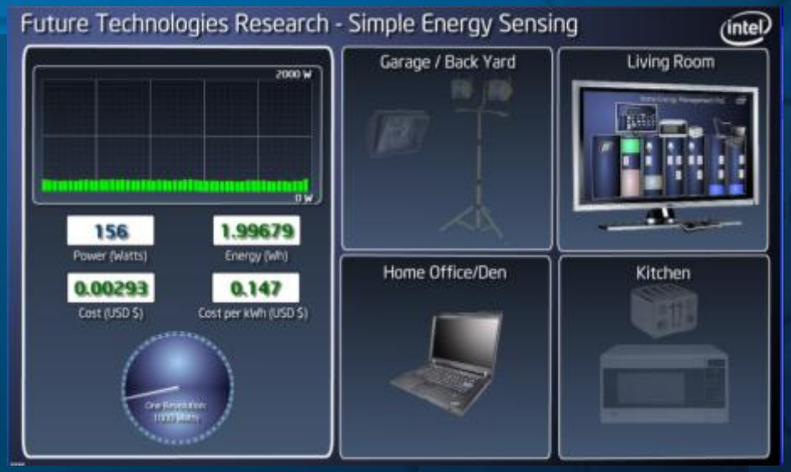
Low-Cost Energy Sensing

Using Computational Signal Analysis To Extract Load Information



Infer Appliance Operation by Sensing AC Line Signals

Simple, Low-cost Wireless Sensor Anyone Can Install



Compute Detailed Home Energy Consumption from Only One or Two Sensors plus Smart Meter data

Optimization of Energy Resources

- Schedule loads and use of storage based on local real-time electricity prices and weather
- Individual homes, buildings and communities
- Initial results: schedule only EV charging
  - Minimize cost, limit transformer power
- Next step to extend to HEMS
  - Controllable appliances, thermal and electrical storage, local renewable generation

Goal: Enabling Consumers to meet their personal energy goals

Smart Buildings

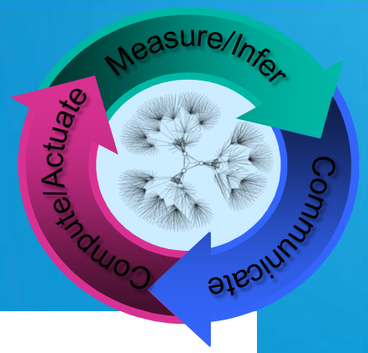
- Buildings are key to electricity usage and CO2 impact
  - 76% of US electricity is used by buildings[1]
  - 43% of CO2 is generated by buildings[2]
- Data centers are critical extreme case
- Industry Challenge
  - Make grid and buildings smarter, make them communicate
  - Today most residential and light commercial buildings are not smart

(1)Energy Information Association; (2)Pew Center for Global Climate Change

Positive Energy Consortium
Positive-Energy Buildings

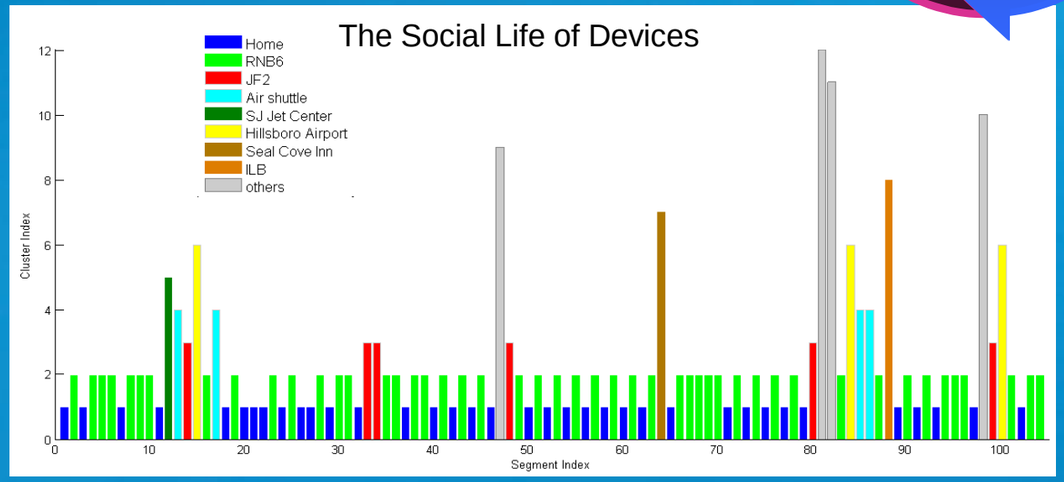
- Companies in all stages of building life-cycle: Intel (IT Architecture Research), Bouygues (construction), Siemens (BMS), Schneider (BMS), Lexmark (IT), Tenesol (PV), Steelcase, Sodexo
- Ten years ahead of regulatory requirements
- Positive energy building :
  - Consumption:
    - 62 KWh/m²/year
    - 65 % less than a traditional building
  - Production:
    - 64 KWh/m²/yr; PV solar panels, combined heat and power generation, bio-fuel furnace
    - 3 projects : Meudon (23,300 m²), 2 planned

Secure, Efficient Communications

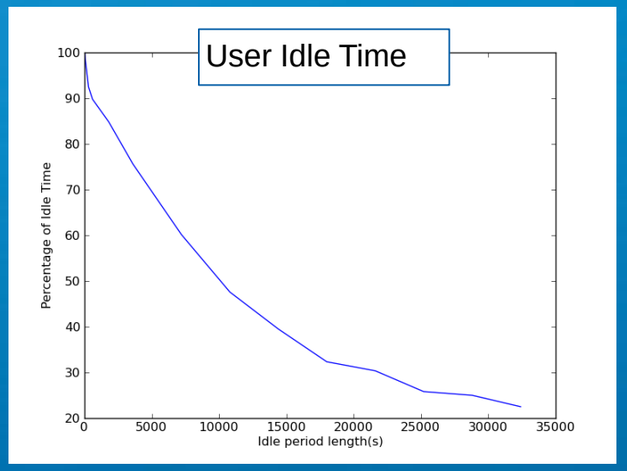


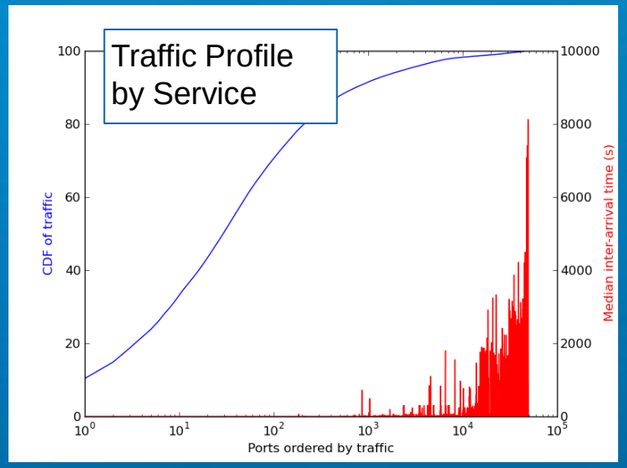
- **Trusted Device Collaboration**
  - Privacy-preserving energy data collection and sharing
  - Similarity-based groupings for self-configuration
  - Trusted coalitions for energy control

  ➔Harvest Energy Savings

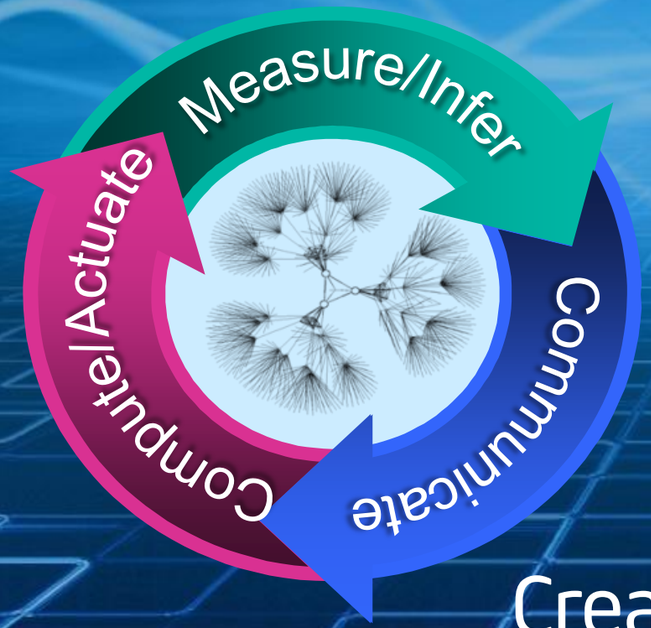


- **Low-Power Communications**
  - Eliminate "senseless" sensing
  - Employ Adaptive Heartbeats to reduce network management traffic
    - Complements CSR Long-Idle research by targeting senders (vs receivers)





Research Drives Innovation.....Standards Drive Investment



Creating a Virtuous Cycle

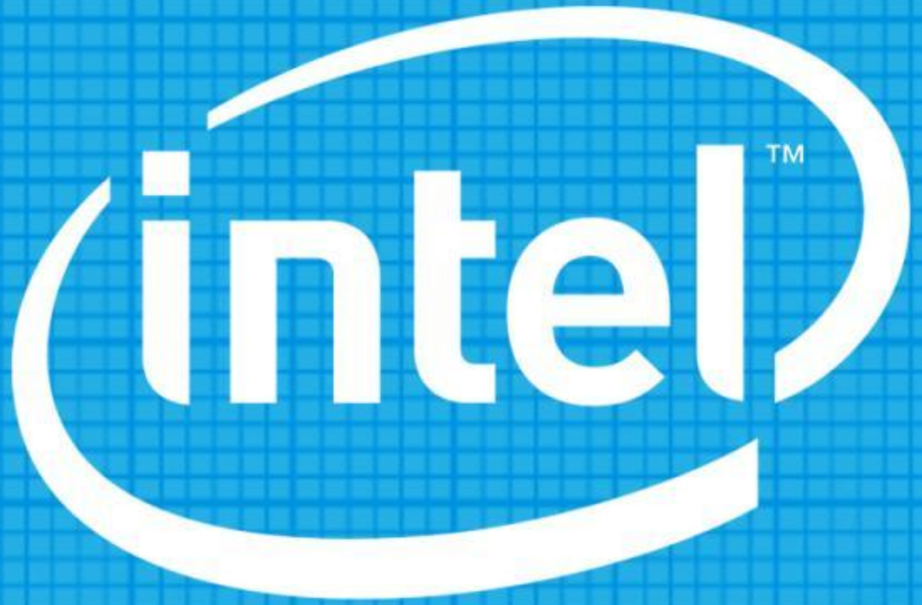
Personal Energy Systems Require Both

Empowering Energy Consumers

- Use technology to inform consumers and change their behavior
- Aggregate millions of small contributions
- Drive a significant change in CO_2 output

Abundant opportunities for developers of Personal Energy Management

Technologies: Sensing, Communications, Analytics
Applications: Personal Energy Services, Micro level Demand – Dispatch, Community Energy 'Gaming'
Standards and Interfaces: Low impact – Low cost, Multi Service transport of secure energy data, …



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