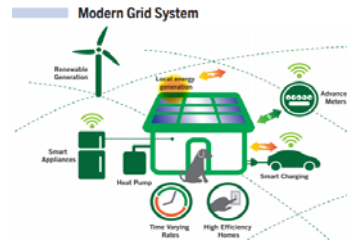




The Future of Energy Efficiency: Intelligent Buildings at the *Edge* of a Clean Energy Grid



**Harvey Michaels, MIT Sloan Lecturer, Research Director
Energy Management Strategy**

At BU Questrom Institute for Sustainable Energy
Earth Week April 19, 2016

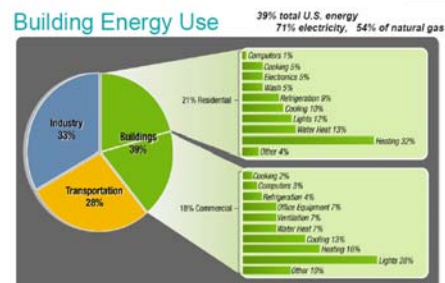
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Qu: What's Interesting about Buildings and the Energy they use?

Over time, the answer has changed:

- **1975: OPEC**
→ **Building Energy Efficiency**
- **1990: Soft Energy Path**
→ **Integrated Resource Planning**
- **2005: Smart Energy**
→ **Demand Response, AMI, Site Solar, ICT**
= Intelligent Buildings

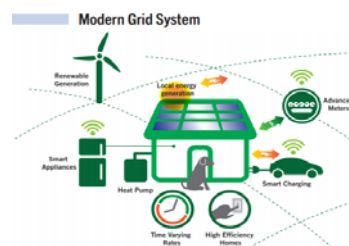
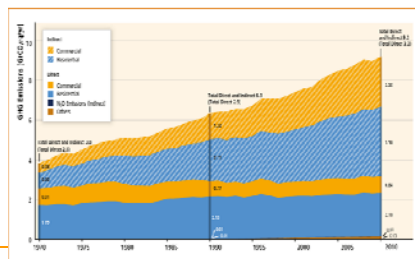


\$25 Billion/yr!!

Going Forward: Intelligent Buildings are at the Center of a Climate Solution



- 1/3 - Buildings account for 1/3 of all GHG emissions.
- 2X - Business-as-usual, building GHG's will double by 2050.
- Half - of emissions can be saved with positive NPV (at least).
- All - buildings need to integrate with intermittent renew. energy
- Zero - Alternatives to achieving deep gains in more than 1 billion homes/buildings - a *challenging objective*.



Building Energy Management – 1970's to Now



- 1975 : OPEC → Building Energy Efficiency
- 1990 : Soft Energy Path → Integrated Resource Planning
- 2005 : Smart Energy → Demand Response, Site Solar, ICT
- Next : Climate Solution → At Scale, All Together

Truth about Climate Change:



*Its Real, Its Us,
Its Bad, Scientists Agree,
There's Hope*

* A. Lieserowitz, Yale



Building Energy, Soft Energy, Smart Energy

At Scale, All Together =

Intelligent Building Energy Management

What is it? Science and business innovations to optimize building energy use.

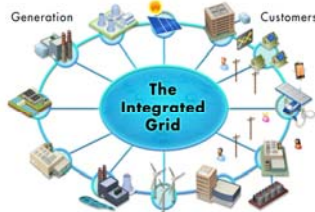


= Building Energy Efficiency

+ Building-to-Grid Systems

+ Carbon-free Site Energy

+ Smart People, Cities

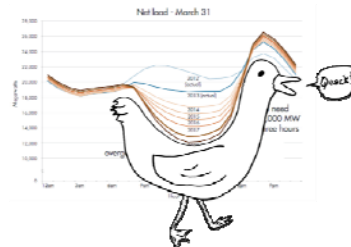


Consumers at the Edge of a Connected Clean Energy Grid



- **Climate Change-driven means:**
 - **DEALING WITH:** Intermittent Supply and “Duck curve” demand
 - **CHOOSING:** Policy/customer preferences for Site Solar, EV’s, batteries, efficient, green, modern.
- **THE PROSUMER:**
Decarbonization, Distributed Generation, Digitization

Solar PV: Distributed Generation



DISRUPTIVE TECHNOLOGY at the Edge of a Connected Clean Energy Grid

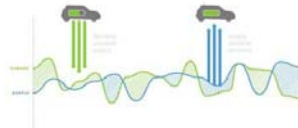


➤ Internet of Things, comes with everything.

- Energy - *sensible, controllable.*
- Enables Settings: *fault detection, thematic control, adaptive strategies*
- Efficiency and grid stabilization - *visible, transactable.*



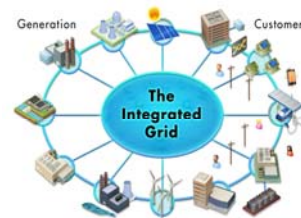
**Question: Internet of Things meets Grid of Things:
Who owns, who controls?**



UTILITIES at the Crossroads of Buildings, Climate, and Grid

Distribution Utility Restructuring:

- From Monopolies → Markets



Question: Where to get backup/insurance energy?

- Utility grid, on-premise, microgrids (real, virtual)?

Most likely answer: All of the Above

➤ Utilities may compete post-monopoly as Comcast does:

- FIOS, Dish/Direct, Apple TV/Amazon Fire/Netflix
- Comcast Innovates → Xfinity, X1 : *Its Still There*
- Utilities who embrace change – *power of incumbency.*

Business Innovations At Scale, All Together



All Together:

Building Energy Management → Full Service/Integrated:

- Building efficiency, DR/controls, Solar/batteries, energy
- Solar pull → Intelligent Buildings → Energy Efficiency

At Scale:

Business, City strategies that Solve the Climate Problem employ:

- No money down, guaranteed positive cash flow.
- Easy, quick, risk free, Guilt.



**Make EM Costless, Riskless,
Timeless, and Visible to all!**



The Future of Intelligent Building Energy Management is bright!

Today's \$25 B building energy industry

- Needs to be/should be \$100 B by 2020
- Needed To Solve the Solvable Climate Problem

Opportunity:

Develop *much more effective* building/climate strategies

- Building Efficiency so far shows some progress, but we need *all of it*.
- Today's Prosumers want 3D's:
Decarbonization, Distributed Generation, Digitization