“Cloud-enabled energy efficiency — an opportunity or a threat?…

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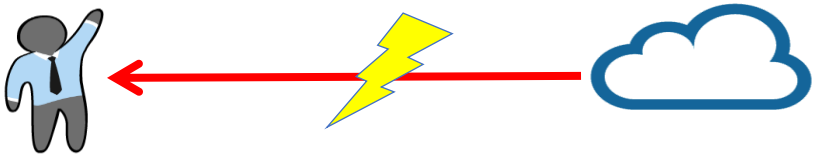


2 linked talks about energy

1. Digitalisation of the economy --> **the opportunity**
2. Principal-agent problems and barriers to energy efficiency → **the threat**

What is Digitalisation?

Advances in technologies, telecommunications and data analytics that are changing the consumer environment

- Digitalisation provides new opportunities for saving energy by using these tools
- Many of the innovations in digitalisation will occur through cloud-based services
- Communications and information will be major new inputs to these services

The word "digitalisation" is used in Europe but not in the United States.

Example of Digitalisation: Jet engine manufacturers now sell “thrust-hours”

Manufacturers of jet engines do not sell engines; instead they sell a service (thrust-hours)*

Results:

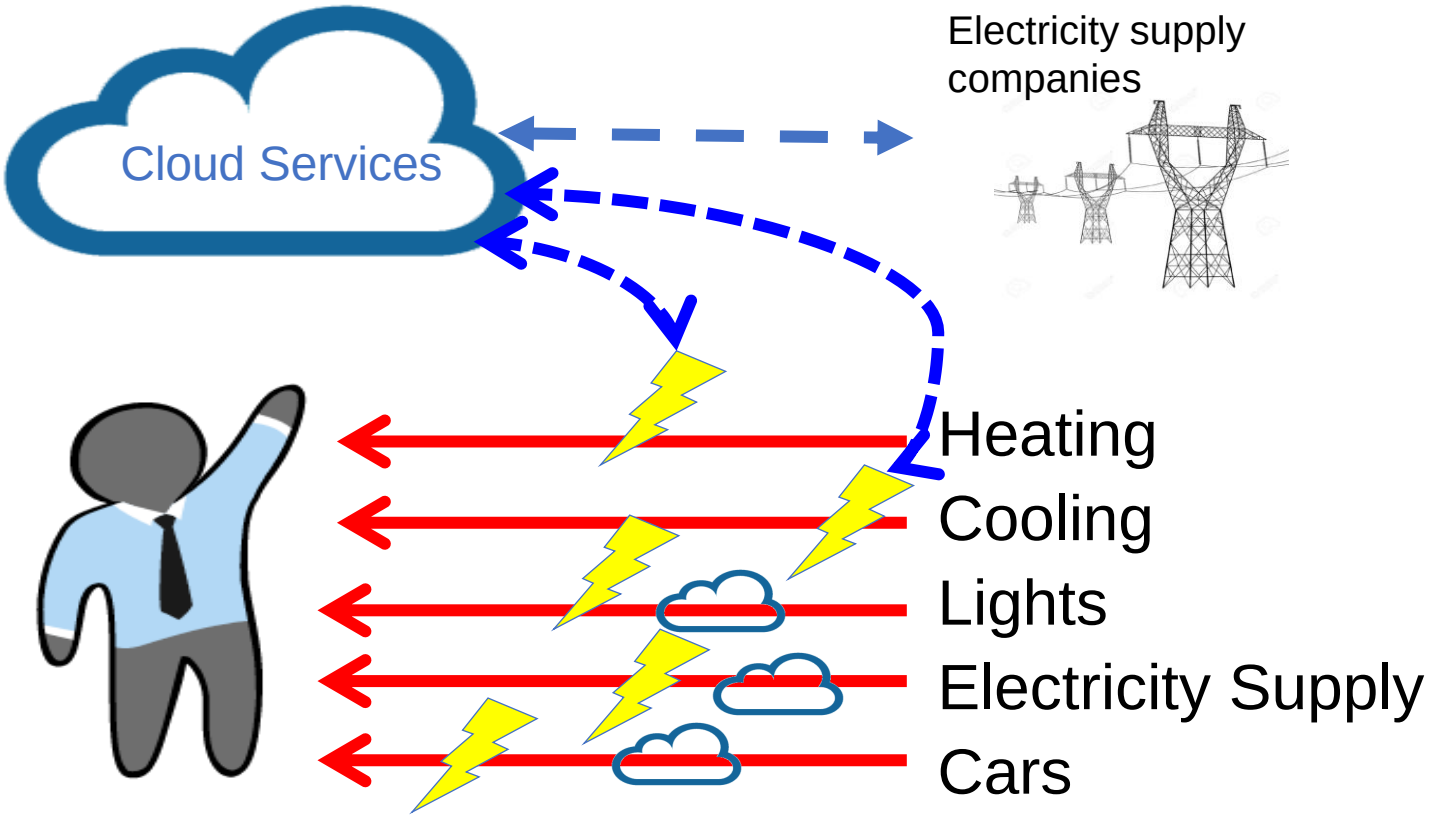
Now the manufacturers must carefully measure the service with more sensors and data collection

Data collection and processing has become a more important aspect of the jet engine manufacturers’ business

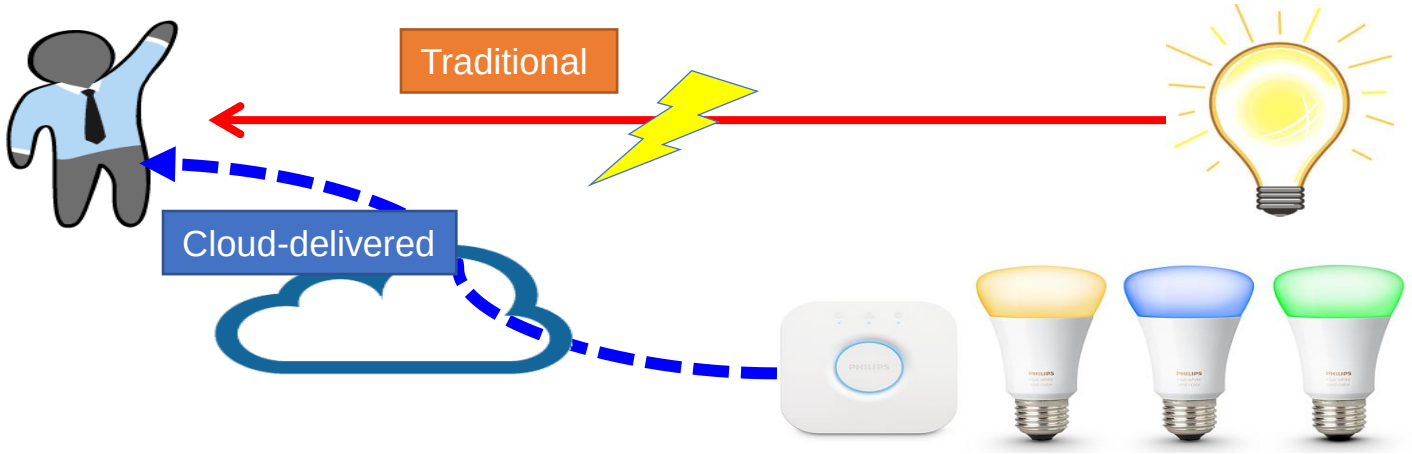
* Also called “power by the hour”

This is an emerging example of digitalisation

New Cloud Services Insert Themselves Between Traditional Appliances and Occupants



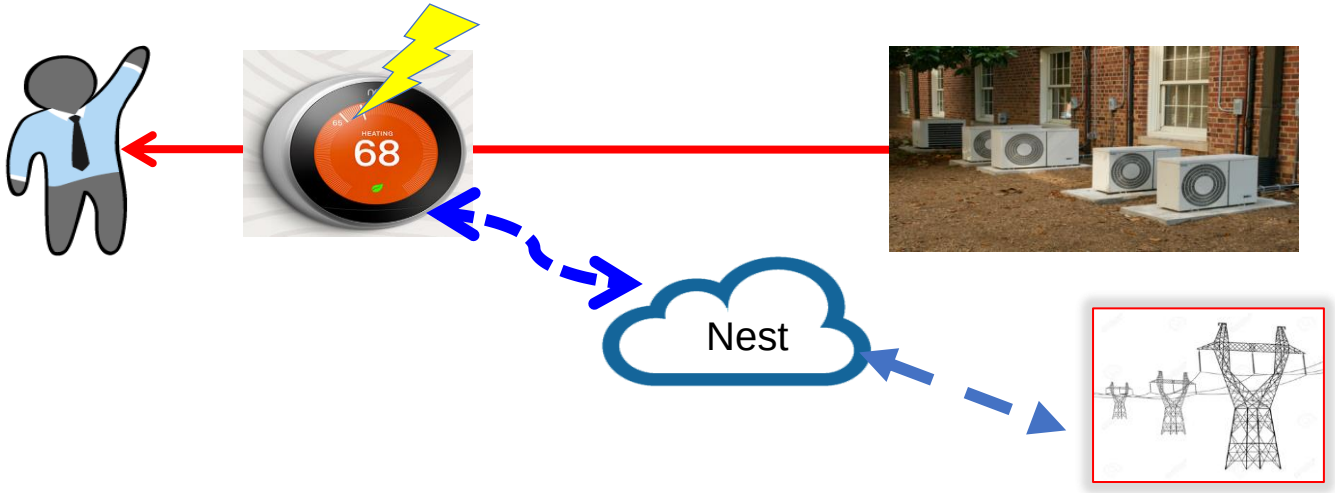
Lighting Services



- Cloud-managed lighting usually saves electricity
- Cloud-managed lighting provide new services, such as “biologically-effective” lighting, which sometimes make people more productive or comfortable
- Newest lighting systems use Ethernet cables to exchange data and to supply power

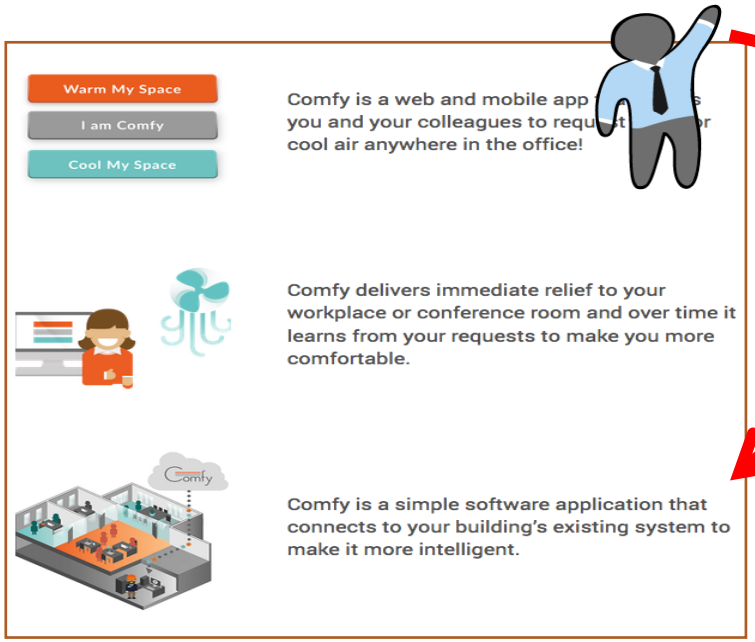
Internet-Connected Thermostats Deliver Thermal Comfort

- The thermostats learn the building's schedule, notice people are present, and use a cloud-based thermal model of your home to minimize heating and cooling energy.
- Heating and AC energy savings = 0 – 15%
- Already in 6 million North American homes and increasing 20% per year
- Millions of thermostats are linked to utilities to provide reductions in peak demand



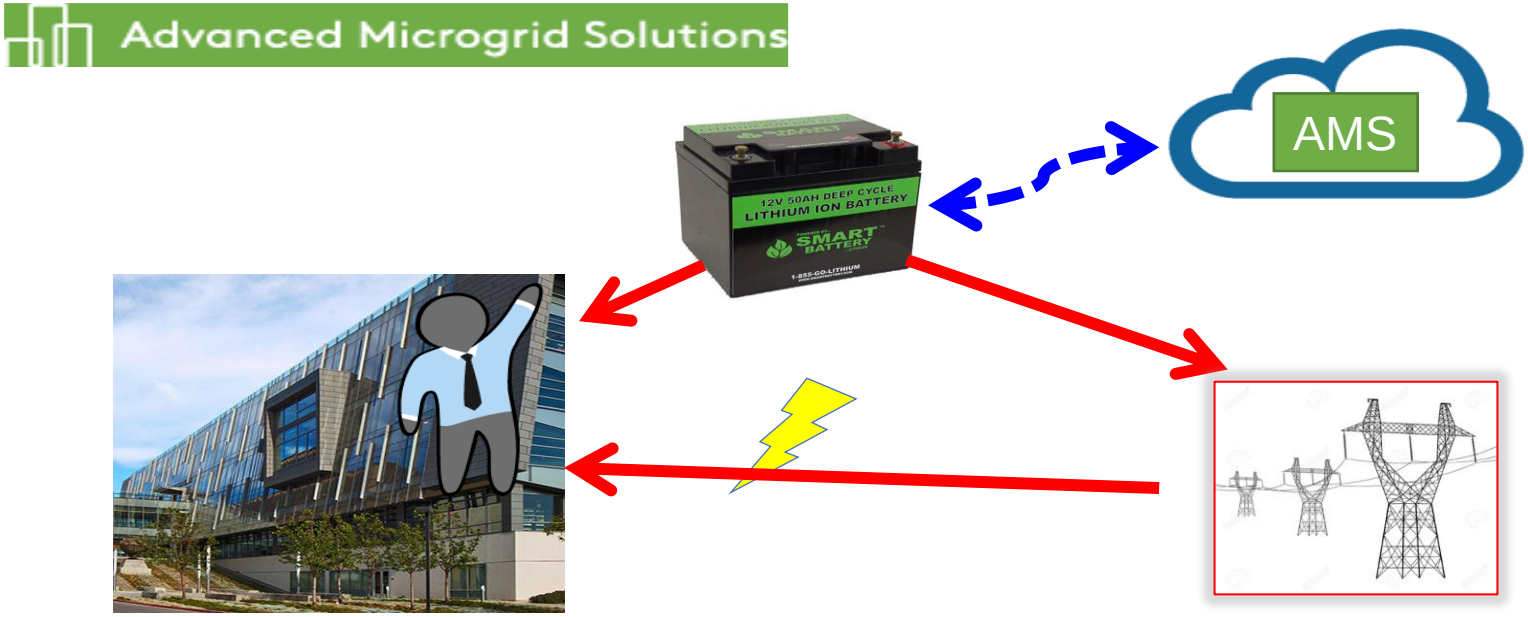
Office Thermal Comfort & Productivity

Comfy works between the occupants and the building's HVAC system.



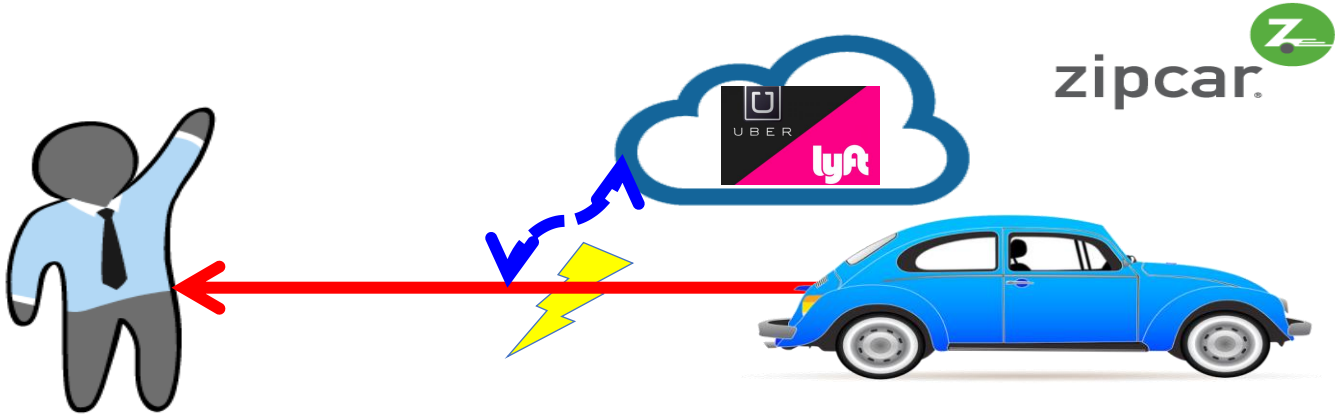
Energy Storage Services

- New California regulations encourage energy storage services (usually batteries) to support intermittent, renewable energy sources
- Advanced Microgrid Solutions (AMS) manages batteries in buildings
  - AMS sells electricity to the building and to the grid



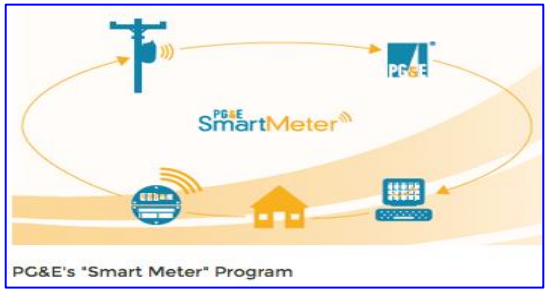
Ride-sharing Apps

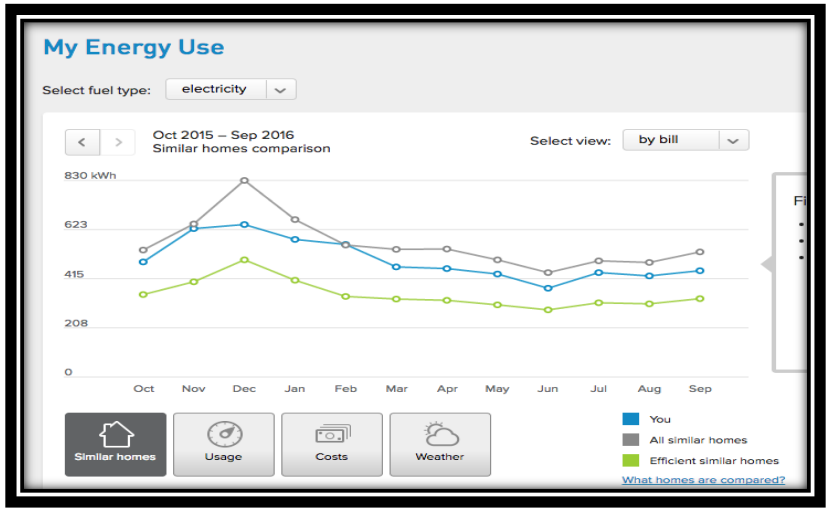
- Many different business models are being created to share vehicles & rides, to transport kids, and provide other services
- Sharing vehicles & sharing trips will save energy, money, resources, and time
  - US cars are idle 95% of time
  - More people share capital and operating costs
  - Fewer vehicles and parking requirements, less traffic
- Few studies have demonstrated actual energy savings



Few Cloud Services Use Smart Meters

- Why?
  - The electric utility company wants the data
  - Privacy protection
  - Obsolete technology
  - Poor security
- Meter-based solutions can't "scale up" to other regions
- **We still need smart meters for time-of-use pricing to support renewables**

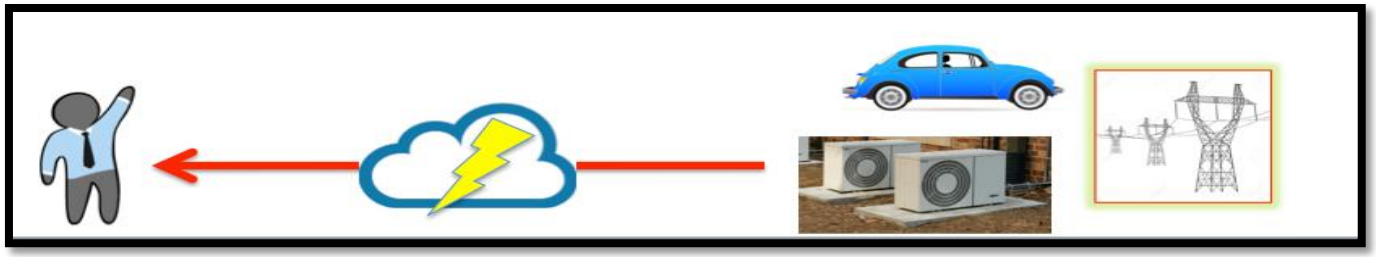




Digitalisation is a new opportunity

- Digitalisation offers new ways to save energy by combining energy and information
- Cloud-delivered services are growing rapidly and some are already commonplace
  - Cloud-delivered services “disrupt” traditional relationship between user and energy-intensive appliances
  - Anecdotal data show energy savings from cloud services
  - But it’s too early to observe economy-wide energy savings

Digitalisation introduces an economic threat: market failures …



Digitalisation

Technology → → Economics

Principal-Agent Problems

Market Failures

Definition: *Situations where the allocation of goods and services by a market is not efficient. Market failures lead to outcomes in which individuals' pursuit of self-interest leads to bad results for society as a whole.*

Categories of market failures:

- Externalities
- Monopolies
- Information failures
- **Principal-agent problems**

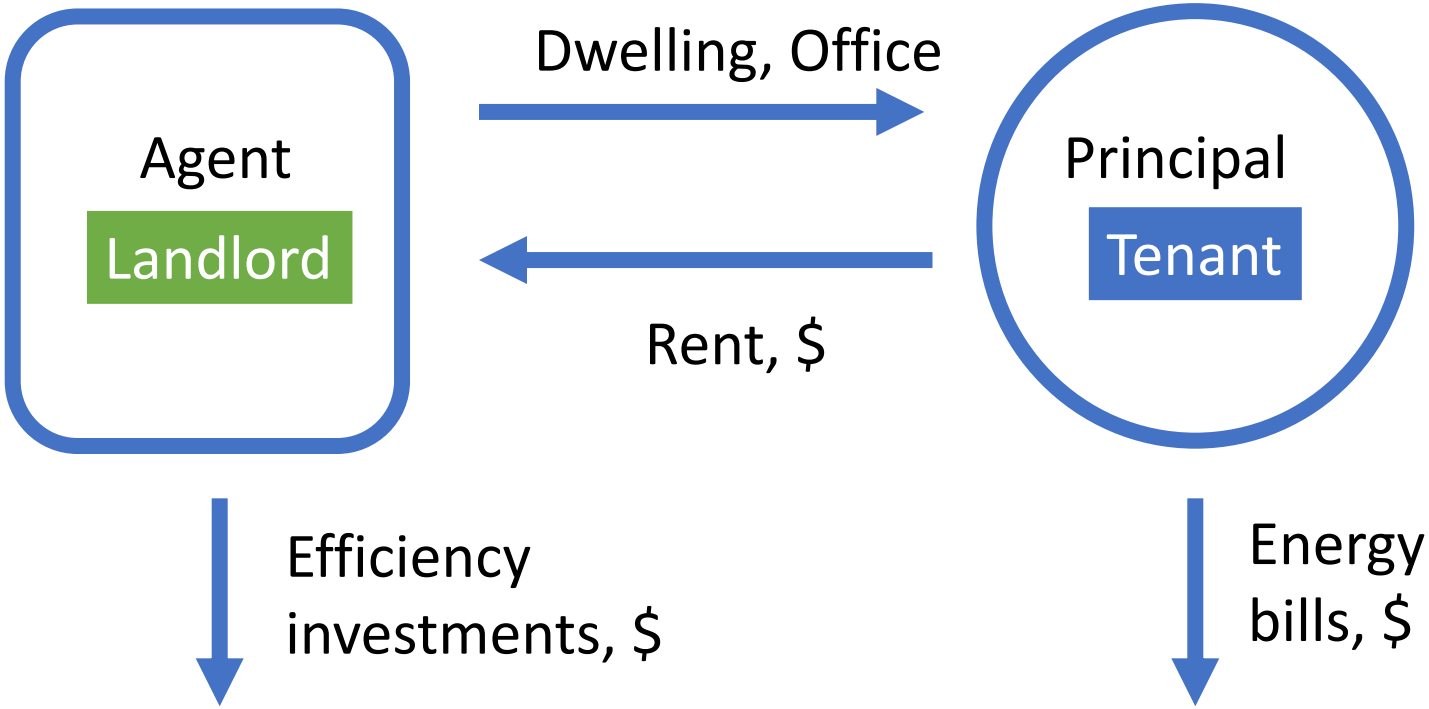
  (also called “split incentives”, “landlord-tenant problem”)

Principal-Agent Definitions

Two entities entering into a transaction, that is, an exchange of money for products or services.

The two entities are:

- The Principal: the entity typically having the money
- The Agent: the entity responsible for investing the Principal's money (ostensibly for the Principal's benefit)



Example of a Principal – Agent Problem

The ice cream company buys the refrigerator but the store pays the electricity bill

What happens when the price of electricity rises?

The Payback Time for Efficiency Investments Doesn't Matter in These Cases

Fraction of product sales where buyer does NOT pay for its energy consumption:

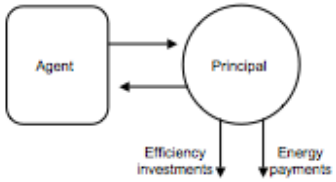
- ~30% of refrigerators
- ~70% of water heaters
- ~99% of TV set-top boxes
- >30% of windows
- >90% of vending machines

Also…

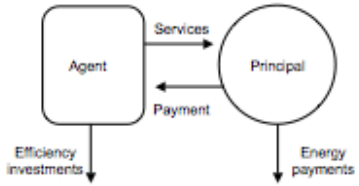
- New apartments, rental cars, leased trucks
- Firms, governments, and organizations where capital budget and operating budget are controlled by separate offices

Different Arrangements of Transactions Lead to Different Kinds of Principal-Agent Problems

Case 1: No PA Problem



Case 2: Efficiency Problem



Example
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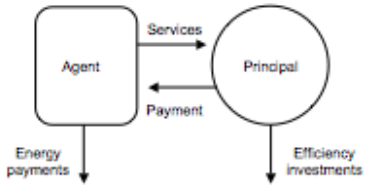
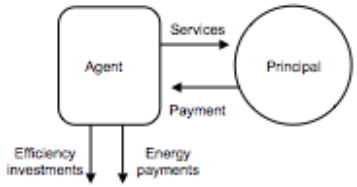
Rental ca
Set-top b
Some lar appliance

Case 3: Efficiency & Usage Problems



Examples:
University researchers
Cars for executives

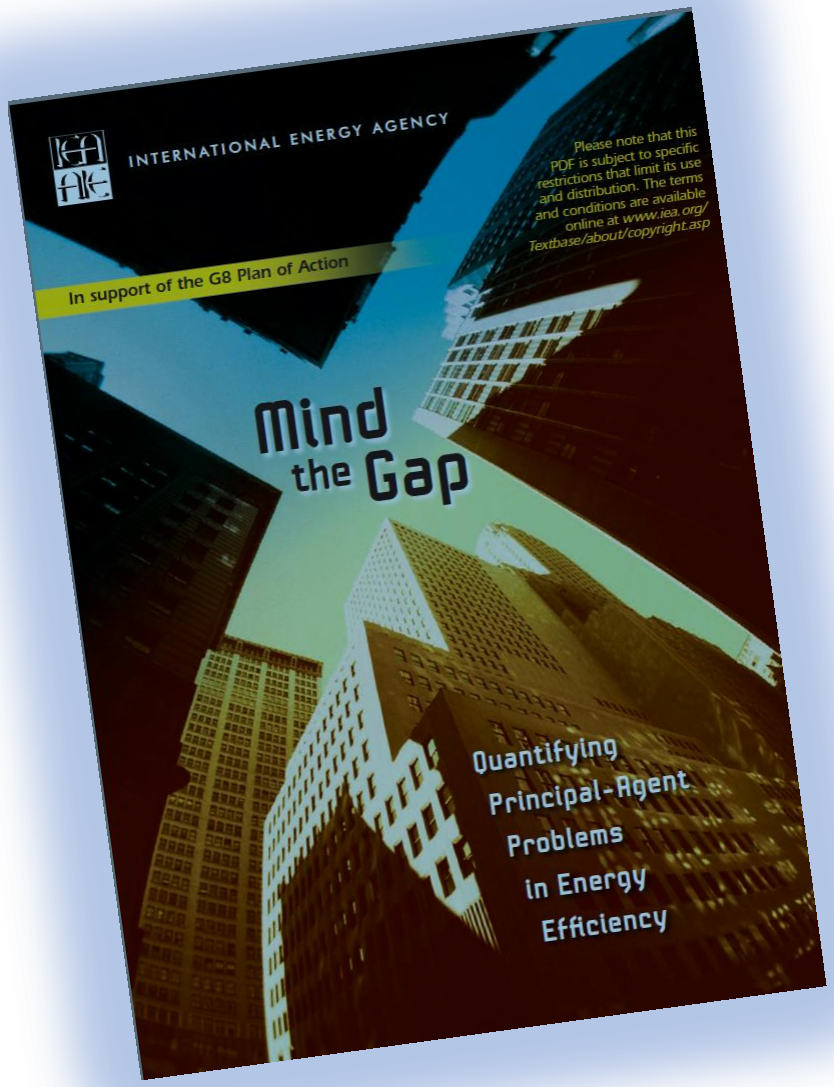
Case 4: Usage Problem



Example
Hotel roo
Some ren arrangem

International Energy Agency Publication

Quantifying Principal-Agent Problems in Energy Efficiency



Japanese contributors:

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Research Questions:

How much energy consumption is affected by this market failure?

How much energy consumption is insulated from changes in the energy price signal?

Global Results

End Use	Countries Examined	Fraction of Energy Use Affected by Principal-Agent Problem
Residential refrigerators	USA	**25%**
Residential water heating	Norway, USA	**38 – 77%**
Residential space heating	Netherlands, USA	**46 – 48%**
Residential lighting	USA	**2%**
Television set-top boxes	USA	**100%**
Company cars	NL	**32%**
HVAC in commercial leased space	Japan, Netherlands, Norway	**17 – 44 – 90%**
Vending machines	Japan, Australia	**44 – 80%**

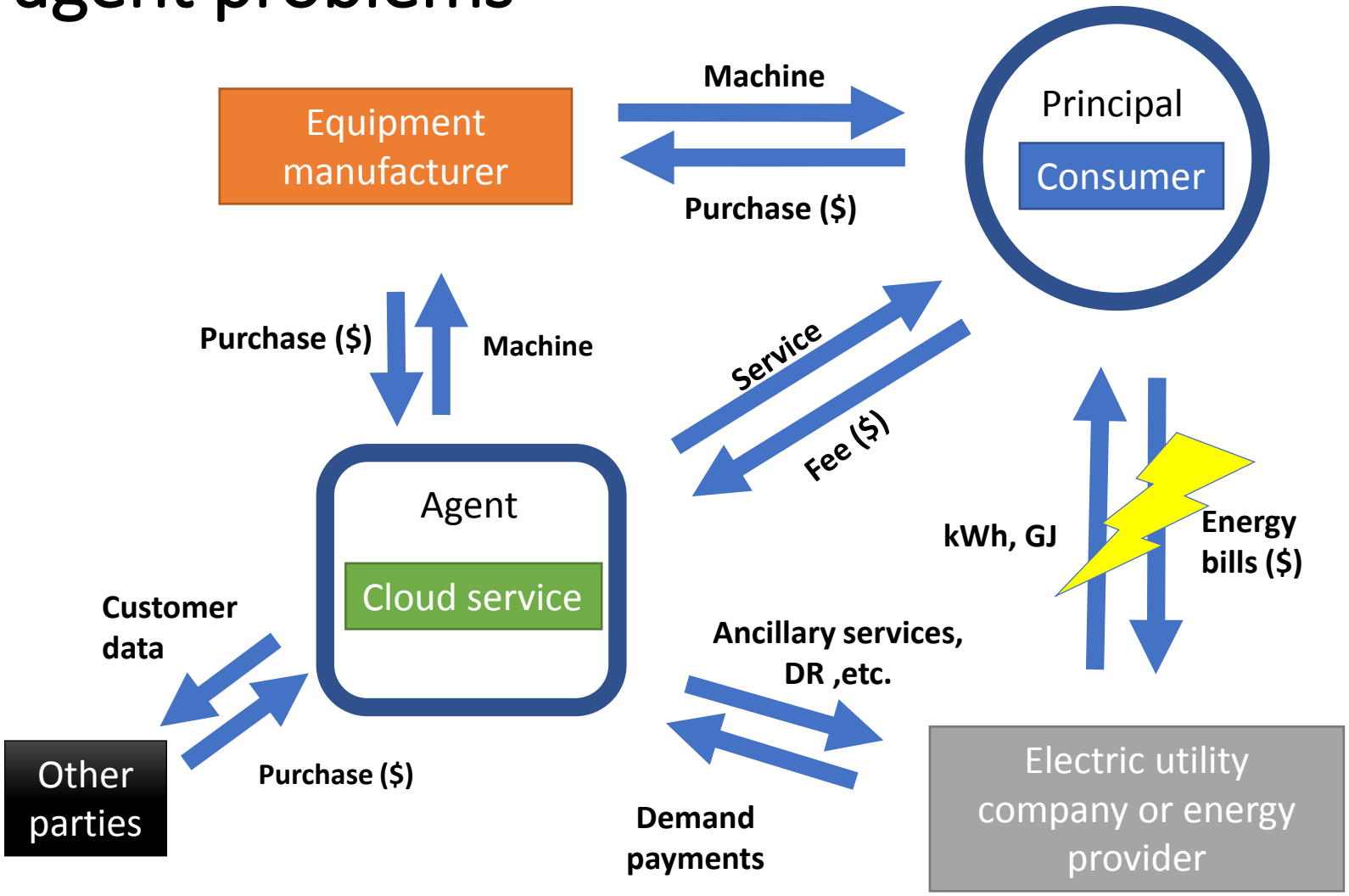
Conclusion:
A large and important fraction of energy use will not fully respond to changes in energy prices (or will respond very slowly).

Price response depends on market structure

These findings are important for policies related to:

- Carbon emissions (carbon taxes)
- Energy security
- Economic growth
- **Digitisation**

Cloud-delivered services create principal-agent problems



Conclusions

Opportunity

- The technology of cloud-delivered services offers many opportunities to save energy
- The services will appear in many different sectors and in many different forms
- To date, there is some evidence that these services save energy

Threat

- Cloud-delivered services introduce new agents into energy-related transactions; this may create principal-agent problems and prevent energy savings