"Cloud-enabled energy efficiency-an opportunity or a threat?"

Remarks by Alan Meier
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Note:
Below are Alan Meier's remarks prepared in advance of his seminar at the Canon Institute of Global Studies on September 4, 2017. They have not been edited for clarity or accuracy. Furthermore, they do not necessarily reflect his actual remarks. They are also the views solely of the author.

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2 linked talks about energy

Thank you very much for the opportunity to speak and share some of my ideas regarding energy consumption, the Internet, and innovation.

The title of my talk is "Cloud-enabled energy efficiency - an opportunity or a threat?" To answer that question, I have drawn upon two areas of my research. The first is the subject of "Digitalisation" and the role in which cloud-delivered services are influencing our economy and its energy consumption. The second area deals with understanding one category of market failures, the "principal - agent problem".

What is Digitalisation?

First, what is "Digitalisation"?

Don't be embarrassed if you have not heard this term - it's new and mostly used in Europe and not at all in the United States. Indeed, I was not very familiar with this term one year ago.

Here is one definition….

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

Europeans - especially the bureaucrats - use Digitalisation to describe the next wave of energy savings. I partly agree: Digitalisation will have an important impact on energy use. But I am unsure about its energy savings.

Let me give an example of Digitalisation and then return to this slide:

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

The traditional business model for jet engine manufacturers involves selling the engines to either the plane builders or the airlines. This arrangement is changing.

Now, jet engine manufacturers lease the engines to the airlines and charge them for the service, that is, "thrust hours" or "power by the hour".

As a result, manufacturers need to collect much more information about how the engines are actually used. The information is needed to accurately measure the service and to calculate how much the airline must pay the engine manufacturer. This requires much more data collection and communication between the engine and the home office. Engine manufacturers now have growing data centers to handle these needs.

There are also energy implications. The manufacturer has a greater incentive to insure that their engines operate at maximum efficiency for the airline's specific conditions. They use data science to spot trends that wouldn't be possible in the earlier arrangement. This incentive exists for the life of the engine or contract.

Back to "What is Digitalisation? "

As you can see from this example, the business is being transformed from selling a product to providing a service. That service involves hugely increased use of communication and computation. The package of these two is often referred to as "The Cloud". It implicitly includes data science to identify trends across engines, planes, or airlines. Sometimes companies will lease computation and Internet connection from another firm, such as Amazon Web Services. As a result, the actual computation may occur in data centers around the world and wherever is cheapest.

New Cloud Services Insert Themselves Between Traditional Appliances and Occupants

Digitalisation will involve innovations like I described for jet engines. Or it may involve new groups entering the market.
I will describe the second situation, that is, where no firms appear that provide cloud-enabled services. They are unique because they insert themselves in between the traditional suppliers and the customers. I have used the cloud and lightning bolt to represent the disruption that these new firms are causing.

Lighting Services

The traditional model involves a lighting manufacturer, such as Panasonic for Philips, selling bulbs consumers. The consumer controls the lights with switches and building energy management systems (BEMS).

Recently, however, new companies have introduced systems that enable people to control individual lights via the Internet (and the Cloud) and their smart phone. The Philips HUE LED is the best known product, but now other firms offer something similar. There are many advantages to this system, such as:

- Control of individual lights
- Ability to modify the color and intensity of a light as desired
- Collection of operating data, user preferences, and behavior

The most advanced lighting systems are even changing the electrical supply system to PoE. This is a communications network technology that was originally designed to carry lots of data and a very small amount of power. But the standards have evolved and lights have become much more efficient. As a result, Ethernet is used to power the lights and - very easily - carry the necessary data with it.

The business model of lighting is changing very rapidly. For example, one company will offer FREE lights in exchange for the data that they can collect about the occupants. This is an extreme case, however, and will probably not succeed. (Remember this example for later.)

Internet-Connected Thermostats Deliver Thermal Comfort

In the traditional business model, manufacturers of heating and cooling equipment sell directly to customers. The manufacturers continue to interact with the customer after the sale through maintenance and repairs.

New firms are now appearing that insert themselves between the customer/end-user and the traditional manufacturer/supplier. In the USA, the most famous firm is Nest, but others, such as ecobee of Canada, offer similar services. About 6 million Internet-connected thermostats have been installed and the number is growing at 20% each year.

What does the Nest thermostat actually do? The Nest is connected to the Internet. Every 5 minutes it measures and transmits to the cloud:

- Inside and outside temperatures
- The occupants' desired temperature - called the "setpoint" on the thermostat
- The number of minutes that the heating system or AC operated.

In the cloud, Nest applies data science methods to learn how the house's heating and cooling systems perform - it calculates the house's "thermal constant" - and how occupants behave. It combines this with weather forecasts to optimally manage temperatures so as to maximize comfort and reduce energy use. These small changes in temperature management reduce energy use 10 - 15%.

At the same time, Nest knows more about people's heating and cooling habits, their equipment, and behavior than the utility company, the manufacturers and perhaps even the occupants themselves. Nest can also tell you the actual temperature in over 3 million US homes at any specific hour. Nest is still trying to figure out how to make money from this kind of information.

One new way to profit is by cooperating with electric utilities during peak demand periods. Nest can reduce AC electricity demand from thousands of units for a few minutes - or hours - if there is an electricity supply emergency. That's why I drew a dashed line from Nest to the electricity system. Here you can see that Nest may decide to operate in a way that gives it more profits (from the utilities) but at the potential inconvenience of its customers.

Office Thermal Comfort & Productivity

New services are also appearing in commercial buildings. Here is one service that inserts itself in between the HVAC system and building occupants. Comfy connects employees directly to existing building heating and cooling systems. It enables more personal control. This system operates through the Internet. Comfy stores detailed information about the building's performance in the Cloud and uses massive computational resources to operate in the most effective manner.

Comfy changes the relationships between occupants, building managers, the HVAC manufacturers, and even the utilities. It's not clear if Comfy will be primarily comfort-increasing or an energy-saving solution.

Energy Storage Services

Grid operators are beginning to give special credits for energy storage capacity. This has created a new market for energy storage services. One of the leaders in this new business is Advanced Microgrid Solutions (AMS).

AMS installs batteries in commercial buildings. It then sells electricity to the building or the utility. At off-peak times, it recharges the battery. AMS promises to reduce the building's peak power charges but not energy.

AMS quickly learns more about the commercial building than the utility. It is in a position to offer other energy-related services.

Ride-sharing Apps

Cloud-enabled services are also entering transportation. Uber and Lyft are the best known ride-sharing services but every country seems to have its own version. They all rely on extensive communication and cloud-based computation to track and optimize travel.

These services are becoming so large and influential that they are disrupting the relationships between automobile manufacturers and their customers. Recent research suggests “millennials” - young people in a certain demographic - are postponing or avoiding buying a car and instead relying on Uber. At the same time, Uber, tesla, Google, and others are developing new vehicles specifically for this ride-sharing market. This also disrupts the traditional relationship between auto manufacturers and customers.

But we still don’t know if these services actually save energy. More research will be needed.

Few Cloud Services Use Smart Meters

Curiously, few cloud-services use data from smart meters (or at least in the USA). Why is this? I think there are at least 4 practical reasons:
• The electric utility company wants the data
• Consumers want privacy protection
• The technology is already obsolete
• Smart meters have poor security
But there are other reasons. First, smart meter data isn’t high enough resolution or quality for Cloud activities (compared to what can be collected and transmitted via the Internet). Second, the solutions cannot be “scaled up” from one region to many other regions. Put another way, each utility has created its own, unique smart meter system.

But we still need smart meters because they allow us to have time-of-use pricing. This will be a key element of a future energy system that relies on renewable and intermittent energy supplies.

Digitalisation is a new opportunity

This is the summary for the first half of my talk on Digitalisation .

My examples show how Digitalisation offers new ways to save energy by combining energy and information.

These services are growing rapidly. Some services - such as Uber - have even become household words.

My examples showed how cloud-delivered services “disrupt” the traditional relationships between suppliers and customers.

These cloud services sometimes save energy, but it’s still too early to say what the net impacts will be.

One of the reasons for uncertainty about energy savings is that Digitalisation introduces an economic threat: market failures …
And this is the topic of the second half of my talk.

Technology →> Economics

So now I will shift from technology to economics.

Market Failures

Most of you are familiar with Market Failures, so I will simply read this definition:

> 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.

There are several categories of market failures. I am going to focus on only one of those: Principal Agent problems. It goes by several other names, including:

- Landlord tenant problems
- Split incentives

Economists have typically minimized the importance of PA problems arguing that they "solve themselves" over time. I would argue that PA problems are pervasive, or at least in the end use of energy. Moreover, they are persistent, that is, they stay around for a long time.

Principal-Agent Definitions

This figure describes the relationship between a Principal - the person with the money - and the Agent - the person who manages the Principal's money. They are connected through a "transaction", that is, an exchange of goods or services for money.

In this example, with a landlord and a tenant, we see how one entity is responsible for the decisions and investments in energy efficiency (such as installing efficient windows or insulation) while the other is responsible for paying for the energy bills. There is no incentive for the agent to invest in energy efficiency because it cannot capture the energy savings.

We hope that the Agent will invest wisely so as not to waste the Principal's money. But, of course, the Agent may have other goals…

Here's an example.
A useful test for the existence of PA problems is: if the price of energy rises, is there any incentive for investments in efficiency?

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

In our studies, we found many situations where the individual responsible for making investments in energy efficiency had little or no incentive to make them because they did not capture the benefits. This includes …

Common cases are landlords, builders of new homes, and even government agencies.

Quantifying Principal-Agent Problems in Energy Efficiency

While at the International Energy Agency I organized a detailed study of PA problems in energy efficiency. There was a Japanese team and it's possible that some of the team is here…

We published a book about our methodology and findings.

We had two major research questions and these are listed:

1. How much energy consumption is affected by this market failure?
2. How much energy consumption is insulated from changes in the energy price signal?

I don't have time to review this book but I will present some of the global results.

Global Results

We found that, indeed, a large fraction of total energy consumption was affected by some sort of PA market failure. This is listed in the table. For some situations, virtually the entire energy use is insulated from the price signal. In other words, if the price of electricity doubles, there's little incentive to improve efficiency.

These results have important implications for many aspects of energy policy, including

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

It also has implications regarding Digitalisation.

Cloud-delivered services create principal agent problems

This slide illustrates the traditional relationships between the consumer - the principal - and equipment manufacturers and the electric utility. The transactions are fairly simple. Since the consumer pays for equipment and energy bills, there is no PA problem.

Now let's introduce Digitalisation and a Cloud-delivered service. There is an agent, Like a Nest thermostat…

Suddenly, there are many new potential transactions between the Agent and the manufacturer, utility, and even other parties. They exchange money, ancillary services (like demand reductions) or buy new kinds of equipment.

The Agent may have very different goals compared to the consumer, and might not even be interested in saving energy. So, we have introduced a new technology with many energy-saving opportunities, we are also introducing a form of market failure. This is the opportunity and the threat.

Conclusions

I have introduced several new concepts in the last hour:

- Digitalisation
- Cloud delivered services
- PA problems linked to energy consumption

You can see how cloud-delivered services insert themselves between consumers and traditional suppliers, creating new relationships. They also create entirely new services that consumers find valuable.

The cloud-delivered energy efficiency services should save energy but, in most cases, we don't have the evidence to be sure.

So you can see the many opportunities created by Cloud-delivered services.

At the same time, we are creating new market failures - PA problems - that potentially lead to inefficient allocation of resources. This is the threat.

I will not try to predict the outcome. However, I am certain that this space will be very exciting and worth watching carefully.

Thank you.