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What Really is 'SMART'?

The term 'smart' has been used within the energy industry for a number of years now and it is clear that the intentions of people to create a 'smart building' either through refurbishment or new construction are driven by the understanding that smart buildings provide their occupants with a better overall environment. As an added incentive, smart buildings and smart systems are being sold as having the ability to create significant energy savings compared to standard building systems. However, with the phrase 'smart' being used to describe so much in the industry at the moment, are the 'smart' things we purchase joining together to create the smart buildings we are aiming for, and therefore leading the sector to the energy reductions we expect? Or are we simply gaining more information streams which show us performance but in reality, don't reduce energy any further?

For a building to be 'smart' it should be developed upon intelligent concepts and intelligent systems. Intelligent buildings have been defined by many as buildings which have minimal human interaction and are responsive to the requirements of occupants, organisations and society. From an environmental position an intelligent building should be sustainable in terms of its energy and water consumption as well as producing minimal emissions and waste. An intelligent building should be healthy in terms of wellbeing for the people using it and able to provide appropriate environmental conditions as required by the building occupant. It could therefore be argued that to take a building from an intelligent building, one which reacts to its occupants' requirements to a smart one, there are three distinct aspects which have to be considered:

- **Longevity**, whereby a building must now have the ability to adapt to changes in usage over time, ensuring it is able to perform a required function throughout its lifespan.
- **Wellbeing**, a building must be able to provide comfort and satisfaction for its occupants. Building users require greater functionality and specific conditions and a building must be able to adapt to these increased requirements.
- **Energy Efficiency**, a building must utilise energy efficiently with minimal to no wastage.

A smart building therefore must have the ability to be able to adapt in response to information received from smart systems within and out with the building, but it should be able to adapt in the long term to account for local and global changes.

The intelligence of buildings has increased over time and buildings now have a number of systems which intelligently control the internal environment. The integration of Heating Ventilation and Air Conditioning (HVAC) control through a Building Management System (BMS) as an example, can provide a stream of data sources which allows the mechanical systems within the building to change the internal environment to suit desired parameters. These systems take information on temperature, CO2 levels, outside conditions and time parameters as a few examples, and utilise this data to ensure the internal environment matches what is set by the system user. Data from a BMS can also be collected and recorded to understand building performance and energy consumption over specifically determined time periods. Lighting control through either Passive Infrared sensor technology (PIRs) or a more complex lighting control system is not uncommon in most intelligent buildings. For many years these systems have developed better information gathering abilities taking a leap forward from simple on and off direct system control to

systems of a more programmable nature. Intelligent systems such as these provide building users with a level of automation and control over their internal environment. The ability of intelligent systems to reduce the energy consumed by a building has been well documented. A BMS can clearly reduce energy wastage by minimising energy consumption when the system is not required but, in addition, the control over energy using equipment has delivered clear savings in energy consumption.

With intelligent buildings developing over a number of years and having the ability to record more and more data streams from both the building and the building users, it could now be questioned if the integrated adaptability of a smart system to do more than what is already available through intelligent systems is any different from what we have purchased historically. When we now purchase something labelled as 'smart' is this simply a product's ability to create increased volumes of information which could, in theory, be used by other systems to produce the adaptable functions we require for a smart building?

There is no doubting that the information we can take from intelligent systems has increased over time therefore it could be argued that smart systems are not in fact 'smart' per say, but their smartness comes from their ability to share information. Smart buildings will over time be developed for different functions, from educational institutions to hospitals, office blocks to leisure centres, therefore the systems which are required to integrate are varied and vast.

The determining factor to achieve smart adaptability comes with the system ability to be truly and completely connected to other systems. Each smart system must be able to provide information in a way which can be used by others to allow that system to make adjustments. A clear flaw in this process is the relationship between the systems and the connectivity,

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which is expected, but in reality doesn't exist. An example of smart integration could be that a car drives up to a building carpark barrier, the security system undertakes number plate recognition and allows the car to enter. As the car is registered to a specific individual the security door is opened with this person's identification. The building management system brings on the heating to a low level as the weather is predicted to be warm in the near future. The lighting in the workspace already booked by this person is brought on at a dimmed level due to the lux levels received from outside. Finally, the renewable systems take information from the grid to determine whether it is more valuable to utilise the self-generation or to sell this back to the grid network. Technical machine language barriers aside, the key question for this evolution to take place in full is which system would take the controlling lead or is this an overarching system which sits above them all? There appears to be very few examples of smart systems which are willing to make adjustments based upon information gleaned from other smart systems as no system wants to fault based upon information feeds that it does not control or install.

For a building to be labelled as truly smart it has to adapt, but this adaptation shouldn't be restricted to instant changes needed by the building or its occupants, this adaptation must consider longer term changes which are required based upon external factors as well as internal ones. Within short term adaptability a building should be able to recognise space usage and alter the building's conditions to suit this usage pattern. For example, increased numbers of people in rooms leads to increased CO2 levels, therefore a building system should be able to recognise this issue and automatically increase ventilation when required to the space, without affecting other spaces nearby. The smart action here is that the systems recognise, through a room booking system, instances where this has the potential to be replicated and alter the room parameters, so the increased levels of CO2 are not reached in the future.

In the medium term, a smart building should be able to adapt to changes brought about by seasonal occupancy or temperature changes

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as well as prediction of routine usage. Examples of these patterns could be increased by numbers of building users during specific weekdays or recognition of traditional holiday periods where building usage would likely alter. The building should be able to utilise information from different systems and adjust the internal environment to account for these changes.

In the longer term, a smart building must develop the ability to adapt to more external global issues. The ability of a building to recognise the effects of climate change and the impact this has on a building or self-generation patterns due to a changing climate as examples is paramount to recognising a truly smart building. However, from research it would seem that there are very few examples of 'smart' technologies utilising information produced by other devices to manipulate their own systems in a building wide fashion to create a truly smart building.

The main question, connectivity aside, is does this save energy? The answer would obviously be based around each system's ability to react to the occupants' requirements in a connected way. Intelligent systems are clearly proven to make energy savings based upon reduction of usage. Smart systems and therefore smart buildings have a more complicated answer to a seemingly simple question. They do have the potential to make energy savings however, it would seem that smart buildings will need time to learn how a building operates before being able to make significant energy reductions. Medium term adaptation and beyond show more realistic opportunities to make energy savings through better understanding of building usage patterns, but also the data collected. Increased volumes of data allows for building learning and better opportunity to adapt to recurring situations.

Although this article does not provide an exact answer to the question of whether a smart building is more energy efficient, it does highlight a number of key areas which should be considered when the word 'smart' is used. Firstly, and most importantly, we should question what more a 'smart' system can do over and above an already intelligent one. If the answer is simply provision of more data streams, I would question the validity of the smart label. Secondly, the inherent point of a smart system is its ability to connect and inform other systems, this should be the key attribute in making it smart. If a so-called smart system is closed in anyway it would be unlikely to contribute to a smart and therefore adaptive building installation. Finally, it would appear that smart is not simply the installation of a piece of equipment, it is that system's ability to change and learn over time, therefore smart systems may not be smart straight away, but become smart as they learn more about the building and its occupants.

The development of smart systems and fully smart buildings is only the first step in the journey. The connection of smart grids to smart buildings leading to smart networks and smart cities is where there is real potential to better manage the grid output and carbon emissions to facilitate a national and global change to the impact that buildings have on the climate.

Author's profile:
Gillian is responsible and accountable for the optimisation of energy sources and active management of the energy consumption, within the context of the University's Energy Strategy. She has recently completed MSc in Carbon and Energy Management and her current field of research for her PhD is based around the development of positive energy campus estates.

Gillian will chair a panel discussion on the topic of 'smart' buildings in the Strategy, Regulation and Compliance theatre at EMEX on Wednesday 27 November at 13:00-13:40.