Constructing *the case for* smart

Buildings, from the earliest of times, have been constructed for the sole purpose of providing a comfortable and safe space. These have over the years developed into complex concatenations of structures, systems and technologies wherein lighting, security, heating, air conditioning and ventilation can be independently controlled by the occupants.

However, it is not enough to simply control internal systems, building owners of the future should also consider the impact of the building upon the electrical grid and environment in general. Hence, the vision of the future for building construction should not be one that is only restricted to the provision of the basic requirements for comfort, lighting and safety, but must also encompass the minimisation of energy costs while supporting a robust electricity grid and in turn reducing overall environmental impact.

What makes a building smart?

Smart buildings are essentially a subset of green buildings – while both have some similar characteristics, smart buildings are more technologically orientated in that they are more dependent upon integrated information systems.

A green building is one that takes into account and reduces its impact upon the environment and the health of its occupants – it is essentially a subcategory of sustainable construction and typically only involves the structure. A smart building, on the other hand, successfully merges building management and IT systems – these can dynamically optimise system performance and simplify facility operations. Integration furthermore reduces the expense and frustration associated with the installation and operation of multiple autonomous building systems.

Thus a smart building is essentially an intelligent space that optimises efficiency, comfort, safety, and more by collecting and analysing sensor data to help building managers visualise information and make fast and precise decisions.

Smart building technology delivers lighting, cooling and/or heating only where and when it is needed. Smart sensors can accurately detect employee occupancy, daylight, temperature, humidity, radiant heat and other variables. This information is fed into a software system which typically combines historical and current data to reduce waste and improve comfort.

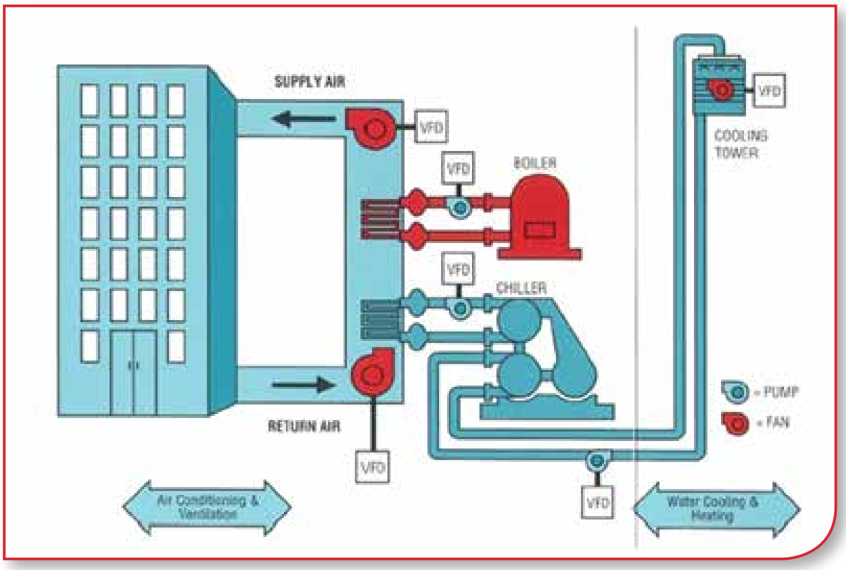
Building intelligence should however not be confused with building automation; thus, it is important to distinguish smart buildings from those that are simply automated. Both scenarios involve the automation of lighting, air conditioning, ventilation etc.; however, the distinguishing characteristic is control – smart buildings are equipped with intelligent systems whereas building automation requires human intervention, either on site or by remote means.

Smart building components

Key elements of a smart building include system integration, advanced building management tools, extensive automation and sensors, energy management, enterprise data management, data analytics, software applications and the leveraging and incorporation of IT.

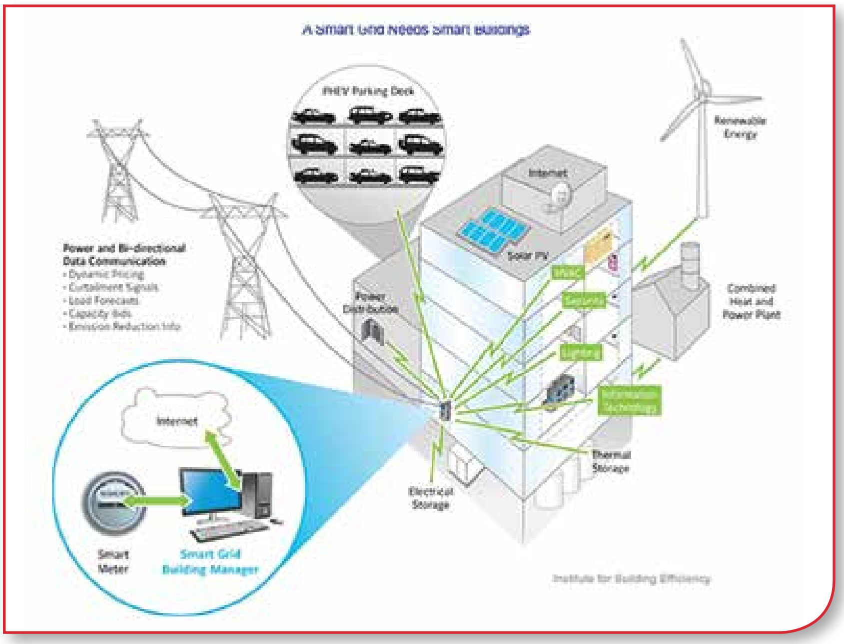
These fundamentals form the basis whereby designers, contractors and manufacturers can address heating ventilation and air conditioning (HVAC), communication and data infrastructure, access control systems, advanced building management systems and sustainability. Legacy HVAC systems (Figure 1) are typically the largest single source of energy consumption in a commercial building.

A legacy building management system also has many disadvantages: these include limited integration capabilities, inadequate analytic tools, proprietary programming languages, a dearth of software applications and legacy user interfaces. A smart building will be equipped with an advanced building management system, which uses an open programming language



▲ ***Figure 1: Typical standard HVAC system***

buildings



▲ *Figure 2: Smart building concept*

where all integration is accomplished via software.

Essentially a smart building can be considered a 'supersystem' of interconnected building subsystems; it has been compared to the internet, which connects computer networks into one larger 'supernetwork'.

Smart building benefits

Energy is one of the largest operating costs – after wages and rent – for any company. Smart meters and sensors can provide real time information and dashboards which enable facility managers to understand usage patterns and thus recognise and implement saving opportunities.

Smart buildings improve employee comfort thereby contributing toward enhanced productivity. Most buildings can maintain the same temperature regardless of outside conditions; however, for optimum comfort air temperature should also be controlled in accordance with radiant temperature and humidity. Smart sensors and software technology can do this automatically, thereby improving comfort and saving energy at the same time.

The advantages also extend well beyond the four physical walls of the smart building. The utilisation of building materials from sustainable sources, combined with reduced carbon emissions as a result of energy consumption reductions, contribute greatly toward a clean air environment. This is further enhanced in instances where smart buildings are also equipped with renewable energy sources such as photovoltaics and wind turbine generators.

Businesses can now operate at a new level of efficiency by using data in new ways, leveraging the connection between systems that until now have been entirely independent. Moreover, these benefits are not temporary, but will extend throughout the entire lifetime of the building, from modelling and design through to renovation and beyond.

Smart building strategy

Old building retrofit: Smart buildings do not have to be new and upgrades need not be expensive. Solutions are currently available to retrofit existing buildings (known as brownfield deployments), and building managers are seeing payback on smart technology investments in as little as six months.

Existing equipment previously presented a hurdle when integrating intelligence into older buildings. Systems, such as heating or lighting, were typically designed as stand-alone and were not built to share data and use proprietary protocols. However, today technologies exist which can address these issues, thus enabling integration of legacy systems and improving visibility into actionable intelligence. These solutions can also help building managers to measure more aspects of building operations, from space utilisation to cross-system security.

Scalability: It makes a great deal of sense to base smart building systems on computer technologies that can scale. This will ensure that processing capacity installed will be able to support the addition of more sensors, grow computing power as required and hence be able to accommodate evolving or expanding requirements.

Manageability: Devices should be connected to a centralised console and managed remotely instead of physically interacting with each device to perform management tasks, such as retrieving data, monitoring system health, or reactively responding to a failure.

Security: Connectivity can bring new risks as data and systems are exposed to hackers and threats. By 2020, it is estimated that there will be around 50 billion networked appliances and sensors worldwide. These will constitute a vast global network of data generating devices known collectively as the 'Internet of Things'. Analysts predict that the ability to attack connected systems and networks will outpace the ability to defend them. Fortunately, solutions (for example, the Intel IoT Gateway) are available in the marketplace today – these can help to provide end-to-end security in both the software and hardware layers.

▲ *Figure 3: Smart community*

Utility networks and smart buildings

Smart buildings will undoubtedly contribute toward a more robust and reliable electricity grid and, in conjunction with smart metering, will form an integral component of a future smart grid evolvement. In addition to improved business efficiency and a far more effective utilisation of available energy, the incorporation of renewable energy sources can provide power, balanced with a network of information, that matches demand with variable supply on a minute-by-minute basis.

In this way smart buildings can become virtual power generators; hence, it is crucial that electricity utilities collaborate and indeed encourage the development of these buildings for the benefit of society as a whole. In addition, the possible curtailment in the ongoing requirement to install additional generation capacity – to meet the demands of a growing economy – could offer distinct benefits for both the utility and the environment.

Load shedding risk

Energy savings, inherent to smart buildings, naturally reduce the load on the country's national electricity grid. Clearly, in sufficient numbers, this aspect can greatly reduce the requirement for load shedding in instances where insufficient generation is available. Furthermore, when implemented in conjunction with smart metering, buildings equipped with renewable energy sources can contribute toward overall generation capacity and thereby help to reduce the requirement for load shedding.

Also, most commercial buildings these days are equipped with diesel generators to ensure that operations can continue during periods of power outages. And electricity generated by stand-alone diesel generators is significantly more expensive than that provided by the electricity grid.

Smart building technology can play a large role during periods of power outages by actively managing air conditioning, lighting and other loads to effectively reduce diesel consumption by a considerable amount – typically 30% to 50%. Added benefits include longer lasting diesel engines and lower pollution thus contributing toward a greener environment.

Smart communities

Smart communities fundamentally involve the establishment of common goals, getting broad participation and having credible measurement. Although much of the focus is typically on medium to large size cities, it is more likely to succeed with smaller communities such as rural towns and villages, neighbourhoods and even campus environments. This is mostly attributable to social cohesion and a sense of local identity that is more prevalent in these communities. Components comprising a smart community are shown in Figure 3.

Sustainability as a means for economic development is also a motivating factor for smart community evolvement and programmes that facilitate public private partnerships, smart grid/building development can certainly create an environmental mind-set that is sustainable.

Electric vehicle (EV) charging stations

Electric cars move people to homes and workplaces, and can also serve as moving batteries in a smart system. Hence these vehicles have potential to feed energy back into the grid at peak usage times. In the medium-term, however, there is only a very small likelihood of EVs operating as batteries for the electricity grid. Still, smart charging will allow EVs to penetrate the market with higher growth rates than the electricity generating capacity needs to grow, since these vehicles can make use of off-peak over-capacities.

Within the smart grid/smart buildings context, EVs require an increasing consideration, not only for the challenges they create, but also for their potential for grid support. In office buildings, a high number of EVs is most likely to park for longer periods. Studies have shown that if the EVs are allowed to charge without control, it will not only have negative impact on building energy management, but also on the distribution grid. Controlled/smart charging will allow a much greater number of EVs in the system without local overload – particularly in regions with limited electricity infrastructure.

These vehicles are certainly an element of the future transition towards a clean and sustainable energy system. With the ability for decentralised storage of electricity, they can even contribute to solving the challenge of levelling out fluctuating generation by shifting demand or re-feeding electricity into the grid. It is thus essential that grid operators understand the grid impact of the potential dynamic energy flows between EV, grid and renewables.

Green building case study – South Africa

Green buildings in South Africa are overseen by the Green Building Council of South Africa (GBCSA), who have developed Green Star SA rating tools (based upon those developed by the Green Building Council of Australia model) to provide the property industry

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with an objective measurement for green buildings.

The Nedbank Newtown Campus, located on a historic brownfield site in the Johannesburg CBD, has achieved a 4 Star Green Star SA rating (February 2015). Sustainable building features include the following:

Energy: The project is estimated, via modelling, to save 48% of energy against a standard regulatory compliant building. This is achieved via efficient chillers, low lighting density and smart controls such as lighting occupancy sensors. Reduced stress on the power grid will be achieved by a 21% reduction on peak load due to the use of thermal storage.

Water: A 31% overall reduction of potable water is estimated over the industry baseline via efficient fittings.

Indoor: The indoor environmental quality is a priority for occupant health and productivity with a 100% designed improvement over regulatory requirements for fresh air rates. PVC within plastics and VOCs within paints will be minimised to avoid the release of pollutants during operation.

Materials: Cement content is to be reduced by 13.4% via the re-use of non-hazardous waste as a cement extender; 93% of all steel used is to come from recycled sources and over 50% of wood will be purchased with a chain of custody from sustainable forests.

Atmospheric emissions: These will be reduced into the atmosphere will be reduced by ensuring that zero Ozone Depleting Potential (ODP) materials are used in insulation composition and manufacture. The back-up diesel generator must comply with best practice emission standards.

Lessons from Germany – smart buildings feeding the network

Germany has adopted a pioneering role with its 'Energiewende' programme for renewable energy transition. The gradual exit from nuclear energy and decommissioning of large power stations have radically altered the German electricity landscape, with a new, decentralised structure emerging. More and more producers – in some cases very small – are generating electricity from wind power, biomass, photovoltaics and hydropower, and feeding it into the public grid.

However, in Germany, wind and sun are intermittent, making them an unpredictable energy source. Such (often extreme) feed-in fluctuations pose a major challenge for grid security and reliability.

Researchers and engineers are working on plans for many millions of energy storage systems, both small and large, to provide the necessary buffer. The batteries of electric cars could be incorporated into the smart grid, for example. Similarly, batteries, heat pumps, thermal storage systems and even thermo-active building materials in smart buildings could provide valuable storage capacity.

Pilot projects are already under way and one such example is a research project sponsored by Germany's Federal Ministry of Economics and Energy, which will run until 2017. The PV Host (Home Storage Systems) project is addressing the technical and economic optimisation of small battery storage systems with a capacity of up to 10 kilowatt hours. These could be used for decentralised storage of excess solar electricity, which would only be fed into the public grid when required. The problematic feed-in spikes that occur during periods of strong sunshine could then be largely smoothed out.

The last word

The generally accepted requirement to keep global warming to below 2ºC will necessitate that global carbon emissions be reduced by 80% before 2050. Considering that the building environment consumes 40% of global energy produced and is responsible for around one third of all carbon dioxide emissions, the implementation of smart grid technology, supported by intelligent buildings equipped with renewable energy sources, is no longer a nice to have, but an absolute need to have.

The value of this technology for emerging markets, especially those where generation capacity is already insufficient, is without doubt huge. The economic ramifications of regular power outages and erratic supply due to over loading cannot be ignored and will continue to restrict much needed economic growth. While the initial investment costs might seem high, in the longer term these will appear insignificant when compared to the potential benefits in terms of sustainable energy sources and improved environment.

Technological progress and falling battery prices should at least help to make the smart grid a more technically feasible and economical proposition within the foreseeable future. With effective insulation and modern heating systems, intelligent buildings are not only highly energy efficient, but as part of the smart grid, will also make a sustainable contribution to providing a country with reliable and affordable power. ESI

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